LETS LEVITATE

The Superconductor Hobby Club
1915 Zachary Drive, Salt Lake City Utah 84116
801-596-3592

Volume 3 Issue 1 February 1989

BOURGOIN'S APPROACH TO HIGH T_c MATERIALS

Recent news has brought Ronald C. Bourgoin's 1982 US Patent (4,325,795, April 20,1982) to the limelight. His patent describes a process for forming ambient temperature superconducting filaments.

He notes that his invention includes the preparation of a molten mixture of conducting and insulator materials; the introduction of the nearly homogeneous mixture between electrodes across which a voltage is applied causing fine filaments to be formed having a diameter within the range of 1 to 100 nanometers. The filaments thus formed give almost no resistance to the passage of electricity at room temperature and thus effectively form an ambient temperature superconductor. The material of choice noted in this patent happens to be bismuth.

Let's Levitate would review additional theoretical proposals on Bourgoin's approach to high T_c superconductivity in future issues. Readers are welcome to contribute their opinions. SHC believes that Bourgoin has had a very reasonable approach of combining Ohm's Law with basic chemical concepts in arriving at a combination of conducting and insulating materials in an atomic scale into resultant higher temperature superconductivity. It will be worthwhile for the rest of the scientific community to evaluate the merits of his approach.

S.C. Forum

o Rodman Publishing Corp., Ramsey, New Jersey, have come out with a valuable trade publication for supporting the Superconductor Industry (with the name Superconductor Industry). Their Winter 1988 issue contains a 1989 Buyer's Guide for the Superconductor Industry.

o The SHC wishes to thank Dr. Rajashekaran of DMRL, Hyderabad, India and Dr. G.V. Subba Rao and Dr. Srinivasan of Indian Institute of Technology, Madras, India for their open discussions and tours of their high T_c research facilities to R. Neelameggham, Editor, Let's Levitate.

Among various research work being done, the efforts by Dr. Srinivasan's Low Temperature Physics Group, IIT, Madras, India, is noted for their analysis of varieties of physical properties of the high T_c materials in trying to arrive at additional fundamental insights into the design of high T_c materials.

o On January 17,1989, Perkin Elmer Corporation demonstrated an X-Ray step-and-repeat lithography system to the U.S. Government and semiconductor industry officials at an X-Ray Lithography Conference. X-Ray lithography is considered to be the next major microlithography technique for manufacturing IC's which are today largely produced by optical lithographic equipment, and will complement the optical lithography.

The technique developed by Perkin Elmer allows many chips to be patterned during a single X-Ray exposure. The circuit pattern is first formed on a thin membrane X-Ray mask. X-Rays are then used to *print* an image of the mask pattern onto the sensitized surface of a silicon wafer from which the multilayers of IC's are fabricated. Specified to perform at a minimum feature size of a half-micron, the System can process wafers from four to eight inches in diameter. It has cassette-to-cassette wafer handling, a small footprint in a clean room, and modular construction.

The system is planned to be shipped to the Solid State Electronics Division of Honeywell, Inc. in Plymouth, Minnesota for pilot production and evaluation. Those interested in further details of this development can contact Edward Bloch (Tel:203-762-6973), The Perkin Elmer Corporation, 761 Main Avenue, Norwalk, Connecticut 06859-0280.

o Physical Dynamics Incorporated, solicits participation in the creation of Superconductivity Database on the compact disc technology of CD ROM for use with personal computers. Fred Durr of PDI (Tel:301-454-8039) writes, *"What we need is the data- both text and graphics"*, on work related to High T_c. Data on everything from basic research, science, theory, and technology to possible product applications, U.S. Government efforts, foreign developments, financing, business development and marketing forces is needed for this CD ROM. One CD ROM can hold as much as 600 megabytes of data - that is over 200,000 pages of text.

Mr Durr adds, *"If you feel you can be part of this by contributing your data for free to this effort and subsequent disc updates, PDI will do the following: 1) coordinate the effort to make the disc, 2) master and duplicate the CD ROM conforming to industry standards, 3) establish a fixed retail price, 4) provide you with three free discs, and 5) establish a distribution agreement which provides a discount on the disc's retail price that is roughly proportional to the amount of material you have contributed to the database. You may sell as many discs as you can to individuals at the full retail price."*

Contact: Fred Durr, PDI, UMCP - Technology Advancement Program, Engineering Research Center, 335 Paint Branch Drive, College Park, Maryland 20742, USA.

o Materials Research Society (9800 McKnight Road, Suite 327, Pittsburgh, Pennsylvania 15237, USA. Tel:412-367-3003) announces that a special workshop to provide a technology update on diamond films has been scheduled for presentation during the 1989 Spring Meeting of the Materials Research Society April 24-28 at the Town and Country Hotel in San Diego, California.

Talks would include: novel methods of diamond film synthesis and characterization; unique properties of diamond films; technological applications of diamond films; and potential investment opportunities. Abstracts may be submitted to one of the workshop organizers listed below by February 15, 1989.

Organizers for this unique workshop are Professor R.P.H. Chang of Northwestern University, (312) 491-3598;

Professor Akio Hiraki, Osaka University, 81-6-877-5111, ext. 4571, and D. Nelson, Office of Naval Research, 202-696-4410. Or contact MRS Meeting Department, (412) 367-3003.

The MRS Spring Meeting Short Courses include: Topics on High T_c Superconducting Materials, Diamond Films, Optoelectronic Materials, and Metallorganic CVD, among other Materials Research Topics.

SCUIPS

o Wada, et al of Hitachi, Japan were awarded U.S. Patent 4,794,688 on Jan 3, 1989 for a "Method of Connecting Superconducting Wires". This patent mainly refers to making near perfect contacts of copper wires with low temperature superconducting filaments, such as Nb-Ti filaments.

o Center for Advanced Materials, Materials and Chemical Sciences Division, Lawrence Berkeley Laboratory, University of California, (One Cyclotron Road, Berkeley, Calif., 94720, (415-486-4755), reports on the demonstration of the Feasibility of High T_c Superconducting Bolometer, in their October 1988 CAM Research Notes.

CAM scientists under the direction of P.L.Richards and J.Clarke, have made experimental measurements of high T_c superconducting films of $ErBa_2Cu_3O_7$, along with detailed theoretical analysis, and demonstrated for the first time that a bolometric infrared detector with very useful properties can be made to operate at liquid nitrogen temperatures.

It is reported that the applications of this new technology include detectors for laboratory IR spectrometers and for observations of bright sources such as the earth, from passively cooled spacecraft. Their work, including the efforts of M.R. Beasley and T.H. Geballe, Stanford University, were submitted to Applied Physics Letters.

o In other pertinent fields, CAM Research Note discusses the work by their researchers T. Lindsey, A.G. Khachaturyan and J.W. Morris Jr., leading to another potentially complete description of the most common crystal structures of intermetallic and oxide compounds. They describe the division of simple crystal lattices into sublattices for each component by *"composition waves"*.

The theory apparently identifies symmetry restrictions on these composition waves that guarantee that the structural energy of the compound has an extremal value with respect to small changes in the distribution of the chemical species. They note that structures that provide energy extrema can then be systematically drawn by selecting combinations of composition waves that satisfy the symmetry restrictions set by the theory.

Since the preferred structures of ordered intermetallics and oxides have minimum structural energy, the theory has been readily able to reclassify a large number of the preferred structures, including the ones with superconducting properties.

Part of their work has been published in Physical Review Letters, vol 61, 215 (1988).

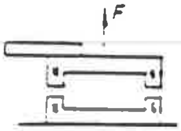
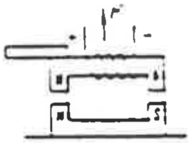
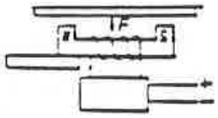
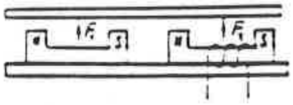
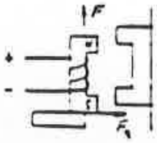
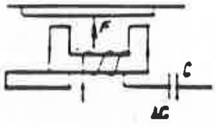
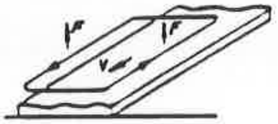
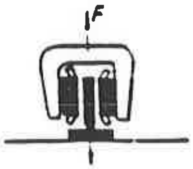
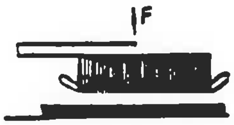
BOOK GLIMPSES

The english translation of the Russian Book on ***Flying Trains*** by G. Zelkin and M. Edelev, published by MIR Publishers, Moscow, is a nice book to have for Superconductivity Hobbyists.

The 1984 Russian Edition, revised when translated into English in 1986, includes updates through that period; but was before the superconductors got heated up. This is one of the many books by MIR Publishers in their series *'Science For Everyone'*.

Fundamentals of trains with magnetic suspension, linear induction principles, as well as some of the magnetic effects on living beings are described in a simple fashion. Several modes of magnetic suspensions are presented, along with advantages and disadvantages of each scheme.

Excerpts from the book are given here:

Levitation Scheme	Operating Principle	Magnetic cushion mm
	Repulsion of permanent magnets	2-15
	Repulsion of a permanent magnet and an electromagnet	2-15
	Attraction of a d.c. electromagnet to a ferromagnetic strip	20-40
	Attraction of permanent magnets and control electromagnets to a ferromagnetic strip	2-20
	Displacement of electromagnet poles and a ferromagnetic strip	2-40
	Attraction of a.c electromagnets to a ferromagnetic strip	2-40
	Use of superconducting loops	100-300
	Expulsion of the inductors of linear induction motors with an asymmetric magnetic strip	50-100
	Repulsion of a bimetallic reaction strip from an LIM inductor	5-15

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Attn: Greg Barnum, (Tel:614-486-0261) SHC members can obtain the Commemorative color poster on American participation in superconductor research, free of charge, but for the cost of postage and handling. This would be a useful addition to any Science Fair Exhibit.

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Hydrides, Superconductivity and Cold Nuclear Fusion

The Superconductivity Hobby Club congratulates the two teams of scientists from Utah for their discovery of Cold Nuclear Fusion, announced to the public in the last week of March 1989. Dr. Stanley Pons, (Chairman, Dept. of Chemistry, U of U, Salt Lake City, Utah), and his revered colleague Dr. Martin Fleischmann (U of Southampton, UK) announced their observations of sustained nuclear fusion reactions in their heavy water electrolysis cell. Similar announcement also came from the team headed by Dr. Steven Earl Jones, (Dept. of Physics, Brigham Young University, Provo, Utah).

Both teams showed the clever application of existing laws of thermodynamics and electrochemistry in arriving at a simpler approach to achieve the nuclear fusion reaction at low temperatures, whereas the rest of the efforts for over forty years has been to simulate the Sun in the laboratory in achieving the sustained nuclear fusion between hydrogen (H) or heavy hydrogen (D, deuterium) atoms. Scientists all over the world are attempting to reproduce and confirm whether that fusion is really possible under these conditions or not. The SHC applauds their scientific approach. This article attempts to shed some light on similar applications of fundamentals in related fields of hydrides, metallic hydrogen and high temperature superconductivity, for over the past 70 years.

It has been perceived worldwide, for over 30 years, that when molecular hydrogen is made metallic, by application of high pressures (in millions of atmospheres), metallic hydrogen will become the material with the highest T_c superconductivity transition temperature. The high pressures were developed mechanically by shock compression. Researchers, have demonstrated conversion of conventional insulating materials into good conductors (MgO, SiO_2, etc). Measurements of high electrical conductivity in metallic hydrogen were reported in 1975. (Vereshchagin L.F., Ye. N. Yakovlev, and Yu. A. Timofeyev, Zhurnal eksperimental'noy i teoreticheskoy fiziki, pis'ma, Vol 21, No.3, 1975, pp 190-193; Kawai N., M. Tagoya, and O. Mishima, Proc. of the Japan Academy, Vol 51, No.7, 1975, pp 630-633; Stewart J.W., J. Phys. Chem. of solids, Vol 1, No.2, 1956, pp 146-158).

Metal Hydrides & Deuterides:

In 1970 superconductivity was noted in Th_4H_{15} and in 1972 T_c values of 9 and 11°K for PdH and PdD respectively were reported. The highest published values of 16.6°K was noted for Pd-Cu-H system in 1974. (C.B. Satterwaite, I.L.Tooepke, Phys. Rev. Letters, **25**, 741 (1970); F. Skoskiewicz, Phys. Stat. Sol. (a) **11**, K123 (1972); B.Stritzker, Z. Physik, **268**, 261 (1974); Hydrogen in Intermetallic Compounds I, Ed. by L. Schlapbach, Springer-Verlag, Topics in Applied Physics, Vol 63 & 64, 1988)

Metal hydrides (deuterides), of different characteristics, are formed using variety of approaches. One, normally starts by mixing gaseous hydrogen and the metal; alternate approaches include, double decomposition and electrolysis. Not all the metal hydrides can be formed at room temperature, by mixing the gaseous molecular hydrogen (deuterium) with the metal.

Now let us look at some rudimentary laws of thermodynamics and electrochemistry. One of the basics indicate that:

$$PV=NRT$$

where, P is the pressure
V is the volume (gas)
N the number of moles of gas
R the gas constant
T the absolute temperature.

One of the basic electrochemical laws, (Nernst Equation), indicates that when an electrolysis is started by passage of direct current across an electrolyte, the voltage necessary to overcome the resistance of a gas film depositing on either cathode or anode, (called overpotential, E_g), is related to the equilibrium reaction which produces the gas film. This is written as follows:

$$E_g = (RT/nF) \ln K_p$$

where, n is the number of electrons transferred in the reaction
F is the ampere-seconds necessary for depositing one mass equivalent of gas
ln is the natural logarithm
K_p is the equilibrium constant for reaction, which is usually a function of the gas pressure
log is logarithm to the base 10

For example, in an aqueous (let us call it *haqueous*--for heavy water systems) electrolyte containing different metal ions, the E_g will define whether hydrogen (deuterium) will start forming on the cathode or the metal ions will start depositing.

Assume an electrode reaction,

$$D^+ + e^- \longleftrightarrow 0.5\ D_2$$

The equilibrium constant K_p is expressed as

$$K_p = (\ \mathrm{SQRT}\ (P_{D2})\ )\ /(a_{D+})(a_{e-}),$$

The activities of the cation and electron are considered to equal 1, simplifying it to

$$K_p = \mathrm{SQRT}\ (P_{D2})$$

Rewriting, and applying the proper units, the gas resistance overpotential

$$E_g \text{ (in volts)} = 0.0295 \log P_{D2},$$
(Pressure, in atmospheres)

For example, the P_{D2} will be 10^{10} atmospheres at $E_g = 0.295$ volts. E_g for hydrogen deposition on Pd is 0.04 v, on iron it is 0.56 v at a current density of 10 mAmp/cm^2 (both in electrolysing 1 M sulfuric acid). This gives an idea of the extent of pressures that can be developed at electrode surface.

The initial hydrogen (deuterium) diffusion can be accelerated in filling the lattice voids with gas atoms because of the high electrochemical surface pressure. Further continuation of electrolysis, i.e. continuing application of surface pressure, can lead to additional packing of gas atoms in the lattice voids. This phenomenon can therefore allow the formation of *difficult to form* hydrides or may even result in nuclear fusion reactions.

With this background, Muller and Bradley were able to demonstrate the formation of copper hydride by aqueous electrolysis in 1926 (J. Chem. Soc., 1669 (1926)).

It has been known that nickel hydride formation by conventional methods requires high temperatures and pressures. Baranowski and Smialowski, however, were able to demonstrate the formation of nickel hydride by electrolysis of aqueous sulfuric acid solutions on nickel cathodes (J. Phys. Chem. of Solids, 12, 206 (1959)).

The production of palladium hydride by gaseous hydrogen reacting with palladium usually results in $PdH_{0.6}$, with a heat release of about 19.5 kcal/mole of H_2. Propensity for palladium to occlude as high as 800 volumes of hydrogen per volume of the metal was known to the pioneers of chemistry in the nineteenth century. The aqueous electrolysis on palladium cathode is known to help diffuse more hydrogen in the lattice, than conventional approaches, resulting in the formation of higher hydrides such as $PdH_{0.9}$ (The Solid-State Chemistry of Binary Metal Hydrides, George G. Libowitzx, W.A. Benjamin Inc., New York, 1965, pp 16).

Several diffraction studies have been done on metal hydrides and deuterides. Most often, the D-D distances, measured in metal deuterides, has been about only 2.1

angstroms, excepting in rare cases like K_2ReD_9 the D-D distance was 2 angstroms. (S.C.Abrahams, A.P.Ginsberg, K.Knox, Inorg. Chem. 3, 558 (1964)). If these measurements were not made under the high electrochemical pressures, one may construe that these distances are not close enough for potential nuclear fusion like reactions.

The glimpses of the work by Pons, as published in newspapers, indicate only a low amount of nuclear fusion products. One should wait to see more of the experimental details in their forthcoming paper in the J. Electroanalytical Chemistry, before additional evaluations can be made.

But, in the meantime, let us discuss other options which could have given rise to the excess heat which is apparently more than the energy input, as has been measured by Dr. Pons, and confirmed by others.

The sparse information presented in newspapers and media thus far, indicates that the measurements based on neutron release rate alone cannot explain the energy excess. In this author's opinion, part of the excess energy can be accounted for by the heat of reaction; while the rest came from the potential fusion type reactions.

Prior to the occurrence of fusion, it is possible that the matrix formula Pd D_x, had a value of $x > 0.9$, with a higher heat of formation than values published till present. E_s heat of solution in D in Pd is 8520 cal/mole D_2, ($PdD_{0.56}$); the published heat of formation of higher x in $PdD_{0.6}$ is about 18200 cal/mole D_2. And as x increases due to the electrochemical pressure, the heat of formation of higher x such as in $PdD_{x>0.9}$ should also increase. This should be accounted for. The nuclear fusion type reaction has a probablistic ratio of occurrence. Furthermore, the rate of neutron escape or secondary gamma ray emission does not tell about the probability of intermediate neutron absorptions, some of which are exothermic and some are endothermic.

Heats of exothermic reactions, such as the oxidation of nitrogen, (from air inside the beaker electrolysis cell), to ammonium nitrite by palladium charged with hydrogen (deuterium) should also be accounted for. (Treatise on Inorganic Chemistry, by H. Remy, trans. by J.S. Anderson, Elsevier Publishing Company, 1956, pp 339).

Unless a complete analysis of electrolyte and electrodes (at least the simple gravimetric change of the electrodes) for intermediate products are made, it is difficult to define the overall energy mechanism.

Additionally, it is not uncommon for the gas film resistance to sky rocket during electrolysis as would in constant current electrolysis. The resistance change in the cell if the electrolyte level is not kept constant is also an important parameter in the energy analysis.

Neale R. Neelameggham

Letter

Dear Editor: February 16, 1989

The following are the very important results on superconductivities by the Superconductor Research of Materials Research Labs, ITRI (Taiwan) within the last two months.

A family of high T_c super-conductors with T_c (zero) above 105°K has been fabricated. The compounds are Tl-Pb-Ca-A-Sr-Cu oxides (A=Y, and rare-earth elements La, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb) with $Y_1Ba_2Cu_3O_y$ - like structure, see *Fig.1*. For Tl-Pb-Ca-Ce-Sr-Cu oxide, T_c (zero) was found to be 95°K. The results represent one of the first cases where chemical substitution has significantly raised the T_c in a known compound.

Single phase samples were prepared from the starting materials with the same cation stoichiometry and annealed at 950°C in

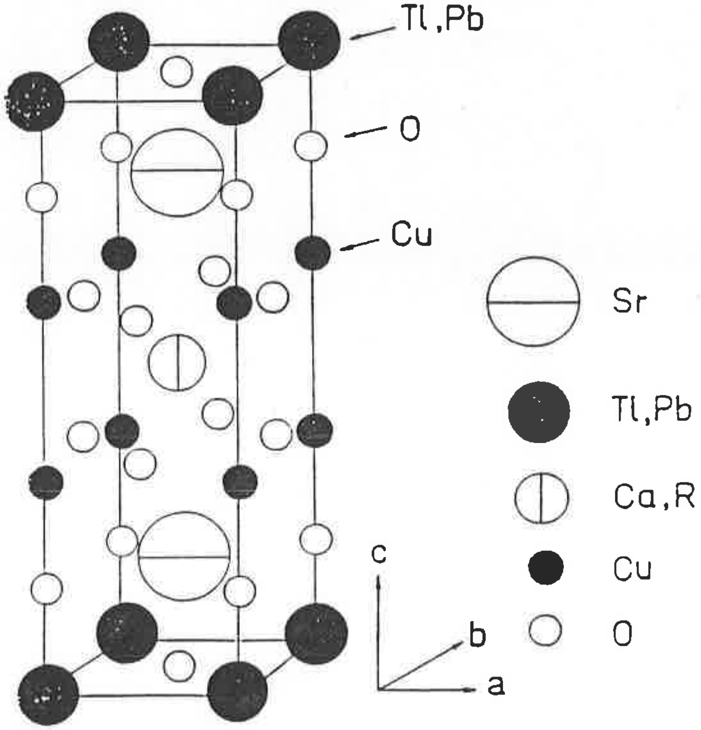
O_2 for 3 h. The sintered samples were found to be remarkably homogeneous both in composition and structure and were highly reproducible and stable with superconducting properties being cooling-rate-independent.

The superconducting phase was found to be tetragonal in structure, of P4/mmm group, and with lattice parameters almost identical to those of $Y_1Ba_2Cu_3O_y$. A comparison with the results on Tl-Ca-Y-Sr-Cu-O system indicated that substitution of Tl by Pb was essential for achieving the superconductivity above 100°K.

Although the six-metal blend makes the system appear to be rather complicated in composition, it is compensated by the relatively simple crystal structure. Furthermore, the preparative conditions are much less stringent than those of the other copper-based high-T_c superconductors.

Articles have been submitted to various Journals for publication.

Yours Sincerely,
P.T. Wu, Acting General Director, MRL
ITRI, Taiwan.



Fusion or Confusion: Power Generation For Tomorrow

The recent advances in high temperature superconductors and in cold nuclear fusion science have made a sensation not only in scientific and technological circles - they have also impacted common people through news media and politicians. The former (superconductivity) set off a flurry of scientific activity across the world with research monies allotted through governments. Cold nuclear fusion has set off more controversy with scientists and engineers from various disciplines arguing, speculating or just listening to rival fusion scientists make claims and counter claims.

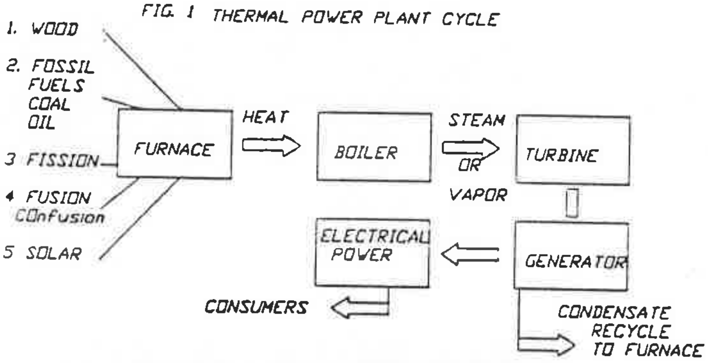
Why all this furor? Since the earliest days, man has continually strived to harness all his resources into producing more energy. From the days of wood and coal fired boiler plants which powered the industrial revolution, through societies sustained by petroleum and to this day's amorphous silicon solar cells converting the virtually limitless "fusion energy" radiating from the sun, the scientific community has been hatching new ways to produce power.

Nowhere is the impact more direct than in the USA, which boasts the highest per capita consumption of energy in the world. Studies have shown, that on a nationwide basis, there is a 70% chance that power generation utilities will be unable to meet peak demand by the end of this century. At current electricity prices this translate to a market of approximately $40 billion by the year 2000! Given such a large market, it is no wonder that any potential breakthroughs in power generation technologies attract such worldwide attention.

Production of Electricity

There are several ways of harnessing various energy sources such as solar, wind, tidal, thermal and hydro power for conversion into electric power. With the exception of solar energy converters, the others use the energy source to eventually drive a rotating device such as a turbine, which, when coupled to a generator produces a.c. or d.c. power. Solar energy is directly converted to d.c. power using silicon cells or, by concentrating the thermal energy in the solar radiation spectrum to drive a turbine. In the latter case the energy conversion is similar to a thermal power plant, which is the focus of this article. A schematic of the thermal plant is shown below (Figure 1):

FIG. 1 THERMAL POWER PLANT CYCLE



In such a plant, different fuels are burnt in a furnace to produce heat, which converts water to steam. The steam is used to turn a turbine, which when coupled to a generator produces electricity. The fuels used are shown in order of their use.

Today's nuclear power plants use nuclear fission reactions to produce the heat required to drive the turbines. The impetus for using alternatives to fossil fuels is because the availability of such materials is finite. For example, according to some estimates the worlds known oil reserves would last us for another 25 to 30 years at the present rate of consumption. Nuclear reactors using fission have been around for 25 years. But there have been enormous problems related to safety and environment. This has slowed down the rate at which nuclear power plants are being installed.

Conventional Fusion Process

Fission reactions generally involve heavy atomic nuclei (uranium) which split to lighter isotopes and in the process release large amounts of energy. Fusion energy on the other hand is produced when light elements such as hydrogen or deuterium *fuse* together to form heavier isotopes and release energy. Such reactions are often called *thermo-nuclear fusion* because these are initiated at very high temperatures necessary to collide the light elements together at high velocities. At these high temperatures the thermal energy kT (k=Boltzmann's Constant) is approximately equal to the potential *wall* which exists between the two deuterons (charged deuterium nuclei). This is shown in Figure 2. The principle processes which occur generally are:

$${}_1D^2 + {}_1D^2 \dashrightarrow {}_2He^3 + {}_0n^1 + 3.25 \text{ Mev}$$

$${}_2He^3 + {}_1D^2 \dashrightarrow {}_2He^4 + {}_1H^1 + 18.3 \text{ Mev}$$

or

$${}_1D^2 + {}_1D^2 \dashrightarrow {}_1T^3 + {}_1H^1 + 4 \text{ Mev}$$

$${}_1T^3 + {}_1D^2 \dashrightarrow {}_2He^4 + {}_0n^1 + 17.6 \text{ Mev}$$

where D,T,n,H are deuterium nucleus, tritium nucleus, neutron and proton.

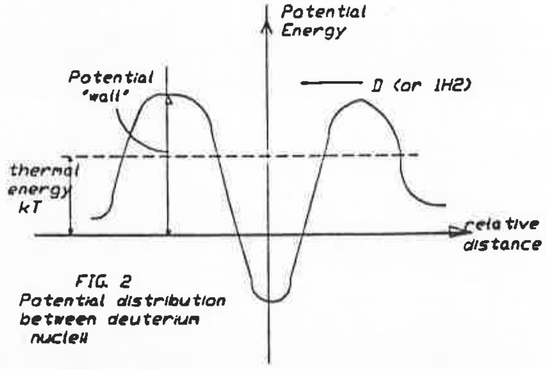


FIG. 2
Potential distribution between deuterium nuclei

Typical potential barriers can be overcome by deuterium nuclei with energies of between 10 to 100 kev. [This implies that kT = 100kev, or that T = 100 million degrees C!] Since the energy output from the nuclear fusion processes are in the Mev range, it is therefore possible for such reactions to be self sustaining if a small proportion of deuterium nuclei fuse.

The problem is that these reactions tend to be runaway - i.e., the collisions multiply in geometric proportions causing enormous energy releases. No material -- manmade or synthetic -- can withstand such enormous temperatures. Scientists have developed a very clever way of *containing* such temperatures: by applying magnetic fields they can restrict the fusing mass consistency of deuterium and tritium nuclei neutrons, protons and ionized Helium gas (plasma). By maintaining a suitable gap between the plasma and the wall of the reactor vessel, the radiant heat can raise the temperature of water to form steam. The high magnetic field is, however, developed by superconductors carrying high currents.

The challenges related to initiating fusion reactions have been formidable by themselves. In a H-bomb, which in principle is identical to a fusion reactor, the fusion reaction is initiated by a small A-bomb (a fission process device). For practical energy production, schemes such as *'Zeta'* are used to initiate fusion reactions. the *'Zeta'* is like a transformer which induces about 200,000 amperes of current in the plasma utilizing superconductors. The plasma heats up due to the resistance offered to the current flow, thus establishing the temperatures required for fusion to proceed.

Prospects for Cold Fusion

Assuming that the recent cold fusion breakthrough has merit, we can compare and contrast this with conventional fusion reactors. The biggest advantage is that "fusion" reaction can be initiated by an electrochemical process where the cathode is *'loaded'* with the deuterium in the lattice. This eliminates the need for relatively expensive and complex schemes for initiating the reaction.

However complications may creep in at the next stage, where, at the threshold loading, the fusion process begins. At the power levels required for economical electricity production, it may be conceivable that high temperatures and pressures may be generated. In any case, for the cathode to be intact, the thermal management systems must keep the temperatures below the melting point of the metal. This may be done by circulating the electrolyte (D_2O or heavy water) itself. In its simplest form this may serve as the coolant for the cathode and also as the moderator to control the emission of neutrons. This technology is well known to nuclear power engineers and may well be adapted to such cold fusion power plants. Beyond this stage, the problems would most likely be similar to those faced by conventional fission reactor power plants.

Fusion Powered Coffee Warmer?

As reported in the media, the cold fusion process appears very simple from the technological viewpoint; this leads to the speculation that dispersed power plants with short transmission lines may be feasible. Apart from techno-economic considerations, the safety related issues are likely to be limiting even if this process is deemed to have less radioactive effluents. After all, though public memories can be short, the aftermath of Three Mile Island and Cheranobyl are hard to forget.

Ashok Khandkar

SC Forum

Materials Research Society (9800 McKnight Rd, Suite 327, Pittsburgh, PA 15237) announces that Dr. Linus Pauling, the only person to receive Nobel Prizes in two different fields, will be the plenary speaker at the MRS's 1989 Spring Meeting April 24-28 in San Diego, California.

MRS has also issued a general Call for Papers for the 1989 Fall Meeting to be held November 27 - December 1 in Boston, Massachusetts. Papers for this meeting may be submitted on or before July 1, 1989. (Tel: 412-367-3003).

A conference on the Advances in Material Science and Applications of High T_c Superconductors (AMSAHTS) is scheduled for April 2 - 6, 1990. A Call for Papers for this conference has been issued; those interested should send abstracts to: Dr. L.H.Bennett, 1990 AMSAHTS Conference NIST, B152, Materials Building, Gaithersburg, MD 20899.

Scuips

The site for Superconducting Super Collider (SSC) has been selected to be in Waxahachie, Texas, with work expected to begin in 1993. It has been noted that this project would cost about 5.9 billion dollars. Foreign governments have expressed a serious interest in cost sharing of this subatomic physics research project. India has agreed to $50 million share; while Japan, Taiwan, Korea and several Western European nations are holding preliminary discussions with USA in this regard. (excerpts from India Abroad, March 17, 1989).

Tokura, Takagi and Uchida have published an article on 'A superconducting copper oxide compound with electrons as charge carriers'. (Nature, vol 337, (1989), pp345). The authors used the quadrivalent cerium to supply the so-called electron excess (instead of the conventionally dubbed electron deficiency in the YBaCuO system). Their work is similar to the work in 1987 by J. Giapinizakis et al (Phys. Lett. **A121**, 307 (1987) who substituted quadrivalent tin for copper to achieve a similar effect. It is interesting that only metal ions are deemed to play a role in the charge carrying phenomenon!!!

A.K.Ganguli, et al (Indian Institute of Science, India) report on the superconductivity in Bi-Ca-Y-Sr-Cu-O (2122) and Tl-Ca-Y-Ba-Cu-O (1122) systems: Effect of substitution of Ca by Y. (Mat. Res. Bull., vol. 24, pp 103-109, 1989).

Yonhua Tzeng (Auburn University) reports on the demonstrated ability to weld YBaCuO superconductor with itself, by proper furnace heating, oxygen doping and annealing techniques. (J. Electrochem. Soc., Vol. 136, 1989, pp 582-583).

First of the US Patents in high T_c superconductivity was awarded to Gawzy G. Sherif, Akzo America Inc., in February 1989. (US Patent-4,804,649). This award was for the chemical oxalate type precipitation route in making the YBaCuO superconducting material.

Hitachi Corp., Japan, announced fabricating a high T_c cable containing thallium compound inside a silver pipe, which was drawn into smaller diameter and its contents sintered at 850°C. This cable was capable of a critical current of 13000 amperes per cm^2 at 77°K. The cable diameter was 2mm.

The TMS AIME Annual Meeting, Las Vegas, (held on February 27 - March 2, 1989), had devoted at least six separate sessions on high T_c superconducting oxides including fabrication and processing techniques.

Critical Materials: national plans

US Senator Reid presented a ten point plan on critical materials. The plan included the following statements about superconductivity:

> 'The Chairman and remaining members of the National Commission on Superconductivity (NCS), should be appointed, as called for in Dec 1988.'
>
> 'The National Commission on Superconductivity should prepare a strategic policy report on superconductivity.'

Critical materials are used in the manufacture of high-tech defense products and hardware. They include chromium, manganese, platinum and antimony. Many of these metals and alloys are imported into the US from South Africa and Eastern Europe.

Palladium is an important material that should be included in this list in view of its potential in cold controlled nuclear fusion.

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Volume 3 Issue 3 June 1989

Superconductor Devices For Analog Signal Processing

Mushtaq A. Syed

In this paper we will describe a new technology, based on superconductors, for implementing analog signal processing devices such as tapped-delay lines, convolvers, matched filters, and mixers. This new technology is conceptually similar to surface acoustic wave (SAW) device technology, which is currently widely used for analog signal processing. This new technology has two key features:

1. Low loss and low dispersion electromagnetic strip lines, and
2. Low noise mixers and high-speed samplers.

This new technology can provide circuit performance that far exceeds that obtainable with conventional room temperature technology. The main disadvantage of this technology is its low operating temperature [1], [2].

Over the past 10 years, Surface Acoustic Wave Devices (SAW) have been widely used in analog signal processing [1]. However, the bandwidths of these devices will probably be limited to several hundred MHz. Hence these devices will not be useful in applications requiring very high data rates and bandwidths extending beyond 10 GHz. For this reason, superconducting devices are being integrated in compact structures for performing analog signal processing tasks, but with dramatic extensions in bandwidths.

Conceptually, superconductive devices can perform all the required analog signal processing functions, viz., delay, tapping, multiplication, spatial summation and time integration. A stripline can be used as delay element while a proximity coupler can be used to tap signals. Mixers can be used to multiply signals. Spatial summation can be performed with microstrips and resonators can be used for time integration [3].

Superconductive Materials

At the present time Niobium-based technology is being used. The key features of this technology are:

1. Niobium (Nb) and its oxide (Nb_2O_5) are mechanically and electrically stable.
2. The critical temperature T_c of Nb is approximately 9.3°K and it is the highest of any naturally occurring element.
3. Tunnel junctions with sharp nonlinearities and low leakage can be implemented.

As a result of these characteristics, Nb-based devices are robust and the circuits are cooled by a liquid Helium bath. Sapphire is used as the dielectric because it commercially available, has low loss and is mechanically rugged. Also, it is compatible with current Nb and Nb alloy fabrication processes.

Delay Lines

Superconductive delay lines can be implemented in microstrip and stripline configurations, as shown in Fig. 1. The delay lines shown in Fig. 1 are constructed from Nb laid on a Sapphire substrate. A spiral delay line can be constructed by reducing the width of the superconductor material to dimensions of the order of 25 microns. The separation S between lines is chosen to provide adequate isolation. The ratio of line width W to substrate height H is chosen to provide a convenient 50 ohm characteristic impedance. The attenuation as a function distance along the line L is $exp(-aL)$ where

$$a = a_d + a_c + a_r + others$$

wherein a_d, a_c, a_r are the dielectric, conductive, and radiation losses, respectively. The loss for superconductive lines is much lower than that for copper and SAW lines.

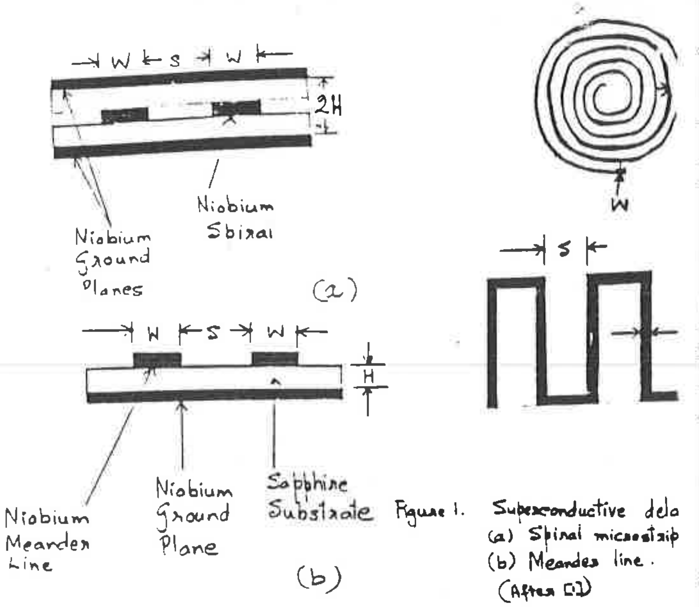

Figure 1. Superconductive dela
(a) Spiral microstrip
(b) Meander line.
(After [1])

Taps

Proximity couplers serve as taps. These are used to sample the waveforms that are propagating in a transmission line. A proximity coupler consists of a pair of transmission lines which are parallel-coupled over a length L. The optimum value of L is $\lambda/4$, where λ is the wavelength.

To construct a tapped delay line, two interleaved Nb spirals are laid down on a Sapphire substrate resulting in a double-spiral dispersive delay line, as shown in Fig. 2. In Fig. 2, the input applied to electrode 1 is coupled to excite a wave propagating in the opposite direction in the other spiral. The coupling takes place between wider regions, where the two spirals are in close proximity.

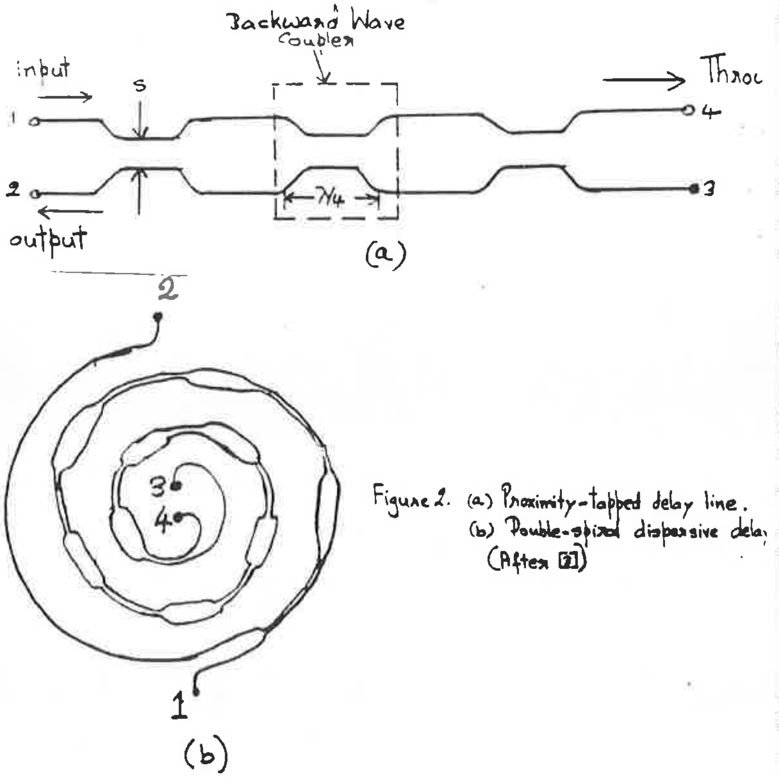

Figure 2. (a) Proximity-tapped delay line.
(b) Double-spiral dispersive dela
(After [2])

Mixers

A mixer is a device that is used to multiply two signals. Superconductive tunnel junctions are used as mixers. In these devices, mixing interactions are obtained by utilizing the sharp discontinuities that are present in the current-voltage characteristics of these devices. By biasing the tunnel junctions in the appropriate region either of the discontinuities can be utilized for mixing interactions.

The basic tunnel junction consists of an insulating layer sandwiched between two superconductive layers, as shown in Fig. 3. A Single tunnel junction mixer has limited dynamic range because of saturation of the tunneling nonlinearity. In order to increase the dynamic range a number of junctions are

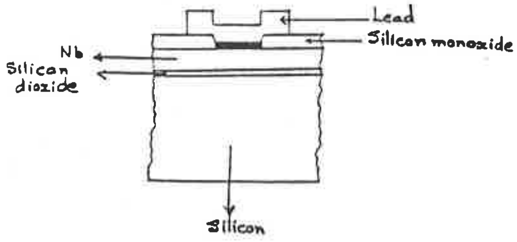

Figure 3. Cross-section of a $Nb/Nb_2O_5/Lead$ tunnel junction (After [3]).

stacked in series. An example of this configuration is the diode mixer ring which has four junctions in each of the four arms of the ring.

Superconductive Convolver - An Application

The convolution of two signals $x(t)$ and $y(t)$,

$$y(t) = x(t) * h(t)$$

* denoting the convolution operation, is given by the expression

$$y(t) = \int_{-\infty}^{\infty} x(t-\tau)h(\tau)d\tau$$

From the above equation it is clear that convolution involves three basic operations, viz., delay, multiplication, and integration. A superconductive convolver employs superconductive transmission lines as delay elements, tunnel junctions as mixers for multiplying signals and a short output transmission as a summing element.

Conclusions

In this paper we discussed the basic superconductive elements required for analog signal processing. The advantage of this technology is that it can be used to process analog signals with bandwidths from 2-20 GHz. This technology can also be used for digital signal processing. Hence it is capable of fully supporting hybrid signal processing architectures.

REFERENCES

1. G. Kino, *Acoustic Waves*, New Jersey, Prentice-Hall, 1987.
2. R.A. Becker, S.A. Reible and R.W. Ralston, "Comparison of Acoustoelectric and Acoustooptic Signal Processing Devices," *Optical Signal Processing - SPIE*, vol. 209, pp 126-133.
3. S.A. Reible, "Wideband Analog Signal Processing with Superconductive Circuits," *Proc., 1982 Ultrasonics Symposium*, vol. 1, pp 190-199.

Haqueous Cell Notes -- Electrolytic Observations

Neale R. Neelameggham

Three papers listed below are available on request from SHC:

'Metallic Hydrogen, Hydrides, Superconductivity and Cold Nuclear Fusion' Neale R. Neelameggham and John F. Reilly
'Chemical Exothermic Reactions, Cold Nuclear Fusion', Neale R. Neelameggham, K. Ganesan and John F. Reilly
'Speculations on Cold Nuclear Fusion' Neale R. Neelameggham

The last article describes how a vanadium cathode disintegrated following three hours of electrolysis.

Recent work on palladium in a dacron bag cathode, as well as, palladium on mercury cathode are interesting in that both demonstrate simultaneous deposition of lithium and deuterium (or hydrogen) under the high cell voltage. Results are being compiled for publication. The current versus voltage curves show a voltage intercept of about 3.1 volts. By alloy plating theories, one cannot dispute the possibilities of co-deposition. The co-deposition can lead to possible nuclear transmutations, such as $_3Li^7$ combining with $_1D^2$ to form $_4Be^9$, if one were to extend Walling & Simmons explanation of P&F's experiment. The above reaction can take place by similar mechanisms as internal conversions, with energy releases of about 16.3 MeV, higher than the reaction between $_3Li^6$ and $_1H^1$ making the 53 day half-life $_4Be^7$.

The palladium on mercury cathode cell, is a well stirred cell, due to gas generation from the bottom of the cell, like a Pachuka Tank. SHC is preparing a proposal, to find higher T_c compounds of the metallic hydrogen family, processed by electrolytic techniques.

The cell was run with D_2O and 0.65M LiOD for five days. The anode was platinized niobium. Considerable current changes were noticed under constant high voltage operations (sometimes as high as 29 volts), co-deposition V vs. I curve was always noticed. The cell acted as a battery during times when power input was cut-off. On the fifth day, when the level came down, distilled light water was used to make up the level. Ten minutes after the start of this reaction, mercury busted resulting in an olive green precipitate. The precipitate has been tentatively detected to be mercurous hydroxide (deuteroxide), mixed with some other compound.

The electrolyte was filtered, the mercury and the filter-cake were recovered. Restarting the electrolysis, following additional distilled water make-up resulted in low current operations (.05 amps at 18 volts) along with the formation of black precipitate (possibly mercurous oxide) on the cathode surface. All these leads one to believe the possible formation of deuteride (hydride) during the initial doping which is followed by hydrolysis of the deuteride (hydride) which can lead to excess heat generation depending on the conditions. The black precipitate turn olive green after a few hours, (at the time of this report, the cell is still on).

SHC wishes to acknowledge A. Chen, K. Ganesan, A. Harami, A. Khandkar, Raj Mishra, J.C. Priscu, A. Ramadorai, J.F. Reilly, and W. Thompson for their support in the research.

SCUIPS

o MRS reports the release of the fourth volume documenting advances in semiconductor related applications of tungsten in the book Tungsten and Other Refractory Metals for VLSI Applications.

The editors, R. S. Brewer (Sandia National Labs.) and Carol M. Monica (Colorado State U), write that *"as minimum feature size has shrunk below the one micron mark, unmet requirements have driven industry to find an alternate method to achieve acceptable step coverage and to manage wager topography issues. Because CVD tungsten meets these requirements, and offers etch barrier protection for headless contacts, diffusion barriers, and improved electromigration resistance, the level of interest in this technology has mushroomed."* Some of the articles do point out the processing problems involved during the development of the tungsten based technology;

This should not come as a surprise to anyone as we are not living in Utopia, it takes time to grow and the curiosity costs due to the desire in reproducing the mistakes from disbelief in other's work is very common -- SHC Editors.

'Tungsten and Other Refractory Metals for VLSI Applications IV 'is available in hardcover or on microfiche. Prices vary between $39 and $57. Contact Materials Research Society, Publications Department, 9800 McKnight Road, Pittsburgh, PA 15237 (Tel:412-367-3012).

o Nova Science Publishers, Inc. (283 Commack Road, Suite 300, Commack, NY 11725), announces three new titles on Superconductivity:

1. Nonequilibrium Superconductivity (Vol. 174 of the Proceedings of the Lebedev Physics Institute). Ed. V.L.Ginzburg. 1988. Price $89.
2. Thermodynamics and Electrodynamics of Superconductors (Supplemental Vol. 1 of above). Ed. V>L.Ginzburg. Price $96 to $115.
3. Electron Fluid Theory of Normal Metals (Supplemental Vol. 2 of 1). Ed. V.P. Slin. Price $89 to $106.

o Arun Ray Ramadorai, a member of SHC, has been working on building a computer controlled 'Hand', with his technology teacher, Mr. Durfee, at Butler Middle School, Salt Lake City, Utah, in their futuristic Lab 2000. The Hand is being built by modular components from Fischer Technique Equipment and interfaced to an Apple Computer.

o The Council on Superconductivity for American Competitiveness will be holding the 1st Annual Superconductivity Technology Transfer Conference on June 23rd at the Embassy Suites Hotel in Washington DC.

o T.J.Richardson and L. DeJonghe, of the Center for Advanced Materials, U. California, Lawrence Labs., Berkeley, have developed a successful cladding of high-T_c superconducting ceramics with aluminum. Their work has been submitted to Applied Physics Letters. It is noted that the superconductor is first coated with a 2 micron layer of silver, onto which electrical grade aluminum is bonded under pressure at 800°K, and the composites show effective very low resistances at 400 amps/cm^2 and are able to withstand thermal cycling to 77°K.

o No new high T_c compounds have been reported in the past three months, other than the effects of substitution with antimony in the bismuth system. It is flabbergasting to SHC why compounding physicists, ceramicists and chemists are still chasing the *cashuns* (cations), and not understanding the peroxide effect. Science is just not carrying out an experiment and theorizing after the fact. Look at the title of article by Cava, Batlogg, et al in Nature (pp291, 25 May 89, Vol. 339), 'Superconductivity at 3.5 K in $BaPb_{0.75}Sb_{0.25}O_3$: why is T_c so low?' What can we say!! SHC's Peroxvite theory report has been sent around the globe to those who requested the report.

o SHC has a compilation of Fusion Discussions, downloaded from US and European University Computer Networks. This compilation is over 250 pages long or a MegaByte and more of floppy disk text files. The efforts by SHC members Lal George and M. Syed as well as the Mount Olympus BBS, and Ken Housley are commendable in this regard. The files include, excerpts from Los Alamos Cold Fusion Symposium, held at the end of May. Those interested can contact SHC, copies in print or floppy disks will be sent at cost of making them and postage.

Confucius Said:

o We at SHC feel that Confucius would pardon abusing his name, for the sake of science. Our EBBS Correspondent reports the following Heavy Humor.

It is reported that the Nobel Prize Committee is creating a new Nobel Prize for Lawyers. This will facilitate some lawyer(s) receiving a Nobel Prize for making most money from the Cold Fusion Research.

U of U sells Cold Fusion Bumper Stickers ($1), Mugs, and Tee Shirts ($14) - what a scientific marketing!

A desert lake in Utah, just north of U.S.50 has so far been called CONFUSION Lake. There is a lobby going on to rename it ColdFusion Lake. But opponents say that the two names mean the same anyway. We wonder if someone has some insight on the geology of this lake.

Our correspondent feels that, Michelle is very good at making the following Fusion non-radioactive Cocktails (no neutrons, gamma rays nor taste):

Cocktail A:
Beefeater on heavy ice. (Heavy ice is available from Snowbird for $1 per gram).

Cocktail B:

North Carolina Moonshine	- 7 parts
Tritiated triple-sec	- 1 part

Shake with ice and strain.
Add heavy water to taste.

Cocktail C:

Galliano liqueur	- 2 parts
Palladiano Liqueur	- 1 part

Served unmixed.

All these cocktails are served in a jar.

o The following came from our Canadian Correspondent:

Nobel Laureate, Dr. Polanyi, showed that he is as eloquent in writing beautiful English Essays, as doing Science. His article on 'The room temperature fusion debate: how science should not be conducted' was published in the Financial Post on May 1, 1989. He showed mastery of the language using choice phrases, such as *"trial by headline", "the saga of room-temperature nuclear fusion", "thinking along heterodox lines", "the mystery of the missing neutrons", "..in science, seeing is not believing", " ...the benefits of fusion to nomadic tribesmen..", "a new panoply of weapons..", " a moral tale..", and "..stooping to ascertain facts...", etc.*

Dr. Polanyi reported that the Canadian mini-science is not far behind. UBC received a grant from BC Hydro, to carry out fusion work. Ontario Hydro has made money by selling over 200 kg of heavy water.

o Media such as the magazines Time, Business Week, Newsweek and networks such as CBS, NBC, ABC, CBC, BBC, NPR, PBS, etc., have experimented in reporting about Cold Fusion Science -- it has become the trend in the recent years, to publish science discoveries/research through popular media rather than through papers in scientific journals!

Maclean's magazine reported that Sankar Das Gupta and James Jacob of Electrofuel Manufacturing Co., Toronto, had achieved startling results based on different electrochemical fusion system, than P&F. They have applied for US patents, for a process that can be controlled while producing a lot of energy.

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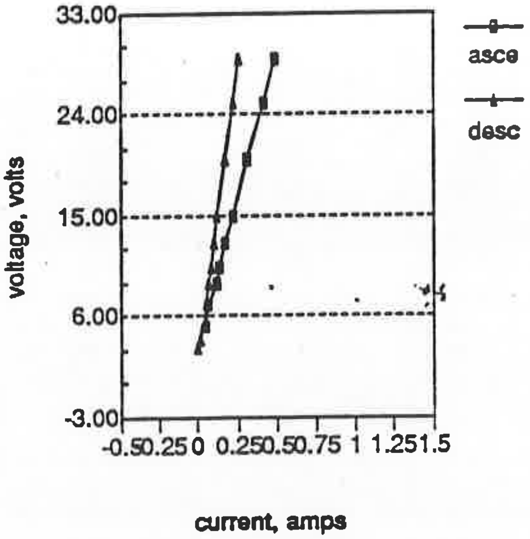
Haqueous Cell Notes - 2

R. Neelameggham.

SHC has been publishing notes on Haqueous cells since April, 1989. Highlights after June 89 are:

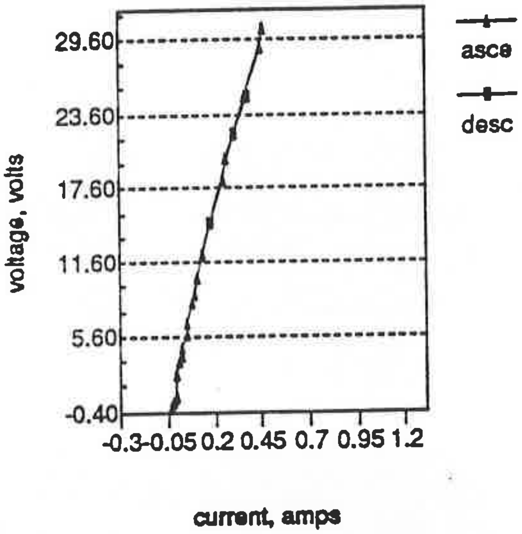
* Lithium transfer to the cathode has been proven unequivocally, by showing a concentration reduction. Also see graph showing decomposition potential of about 3 volts, in the current versus voltage curve below:



* Liquid scintillation counter measurements can be in error if the alkali is not neutralized (SHC, London, Canada.)

* There is evidence of overcharged battery reversal which is undetected by external lead voltage/current measurements. In the cell using mercury as the cathode, the battery reversal inside the cell is capable of plating mercury on the electrode which is initially the anode during the charging period.

See the following figure showing negative I vs V:



* Note must be taken of SHC's work which demonstrated the breaking of vanadium cathode in 3 hours. The club has obtained samples of Ti-15-3: a new Cold-Formable (fusible??) Sheet Titanium Alloy for additional experimentation. This alloy contains 15 % Vanadium. J.O.M., November 1986, has an article on this alloy by H.W. Rosenberg.

Variable Temperature Exothermal Power Reactor

(Inventors: R.Neelameggham, J.F.Reilly, M.Ciomek, G. Ramadorai & K. Ganesan: April 14, 1989. Additional examples June 89. Patent Applied for.)

Objective

This invention relates to a process of generating net electrical power utilizing vapor driven turbines using electrolysis of water or heavy water; where exothermic reactions (chemical and nuclear) are made to occur at the cathodes which in turn fuel the vaporization of coolant used to drive the turbine generators. The reactor equipment is designed to be able to operate at a variety of temperatures to suit the needs of existing power generating turbines.

Prior Art

Storage of hydrogen as hydrides with reversible desorption possibilities in many metals, alloys and intermetallic compounds have been known over the past sixty years. Electrochemical methods of hydride formations are known since 1926 [*Muller and Bradley, J. Chem. Soc., 1669 (1926); K.N. Rai, et al, Proceedings of IV World Hydrogen Energy Conference, Pasadena, California, 1245 (1982); Neale R. Neelameggham, Let's Levitate, Vol.3, Issue 2, (1989).*] Techniques of storing hydrides in thin film catalytically coated containers have been tested [*H.Wentzel, et al, J. Less Common Metals, Vol 89, 489 (1983); Y.K. Vijay, I.P.Jain, J. Less Common Metals, Vol 106, 263 (1985).*] Several of the above principles are applicable to deuterium compounds as well [*The Solid State Chemistry of Binary Metal Hydrides, George G. Libowitz, W.A. Benjamin Inc., New York, 10 (1965).*] · Unusual high exothermic reactions have been observed in the electrolysis of aqueous sulfuric acid solutions using lead cathodes have been observed over sixty years ago. [*A Treatise on Inorganic Chemistry, H. Remy, trans. Anderson, Elsevier Publishing Company, Vol I, 43 (1956).*] Possibilities of partial controlled nuclear fusion in the electrolysis of heavy water (deuterium oxide) have been claimed by the teams of M. Fleischmann and S.Pons, and of S.E. Jones (Press Releases, March 1989). Possible mechanisms for high exothermic heats of reactions with 2.5 times the normal combustion of hydrogen and oxygen have been mentioned [*Neale R. Neelameggham & John. F. Reilly, May 1988.*]

Electrolysis of water and heavy water in alkaline media have been known for over sixty years. Most of these electrolyzers are designed for efficient hydrogen and oxygen separation, and do not take advantage of excess heat generatable by various chemical reactions. The present invention describes a novel method of utilizing the excess heat generated.

Description

Figure 1. shows a cross section of the Exothermal Reactor. This is a novel reactor, wherein either water or heavy water can be electrolyzed at any temperature or pressure, produce the exothermal heat. The exothermal heat is conveniently removed by vaporizing a coolant and sent to turbines to generate power or to create a motive force such as for automobiles or ships or planes.

In this novel reactor, the electrolyzer (1), generating hydrogen (or deuterium) at the cathodes (3), and oxygen generated at the anodes (2), are not separated by diaphragms. The products are allowed to partially or fully recombine inside the same vessel (1), without an explosive reaction by control of the partial pressures of steam (or heavy steam), oxygen and hydrogen (deuterium) in the vapor space above the liquid electrolyte (6). Thermodynamically, the heat of combustion of gaseous hydrogen and gaseous oxygen in producing liquid water is only -68.4 kcal/mole of hydrogen, which is slightly above the heat of decomposition of water. However, the nascent or atomic hydrogen (deuterium) dissolved in water reacts with oxygen, the minimum heat generated is about -170 kcal/mole, creating an excess heat than supplied to the system. This heat is continually removed by the vaporizing coolant to drive the prime mover or generator. The total pressure of the system and the cathode material are varied to effect operation of this unit at the desired temperature. The pressure is adjusted utilizing the valves (7) and (8).

Beyond the atomic hydrogen (deuterium) reaction with oxygen, special fusion type reaction rate augmenting system such as induced magnetism, using the magnet (5), surrounding the electrolyzer and superimposition of alternating current as required on the electrolyzer direct current are also included (not shown).

One method of coolant flow into the system to remove the heat generated is shown in Figure 1. Other similar combined heat exchanger-electrolyzer combinations are also part of this invention. The coolant flows through feed head (9), through tubes (or plate channels) (10), into the cavity inside the cathodes, and vaporizes along the inside surface of the cathodes, flows out through the vapor discharge pipe (11), to drive the prime mover.

For simplicity, the cross section shows only two sets of anode-cathode pairs. The size of the unit and the number of anode-cathode pairs can be varied to suit the needs of the power generation capacity. Each anode (2), is made to surround the cathode (3), in a coaxial fashion. The geometry, whether rectangular plate or circular tubular shape can also be varied depending on the heat exchange requirements, without deviating from the principle of the invention. Each anode (2), is kept submerged below the liquid electrolyte level (6), to facilitate release of oxygen bubbles through the liquid in the

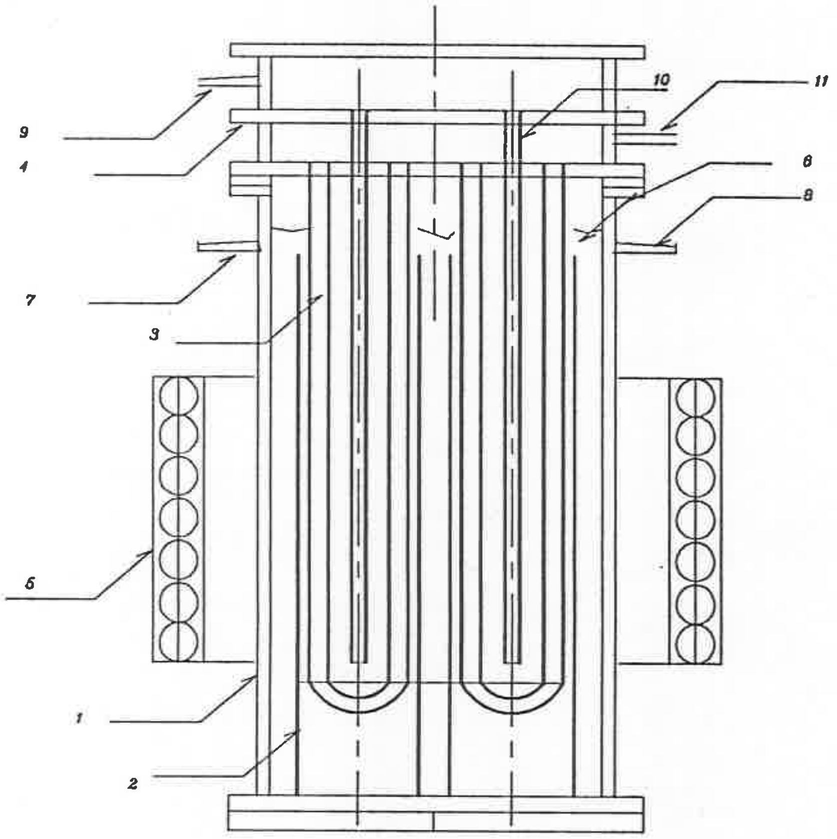


Figure 1

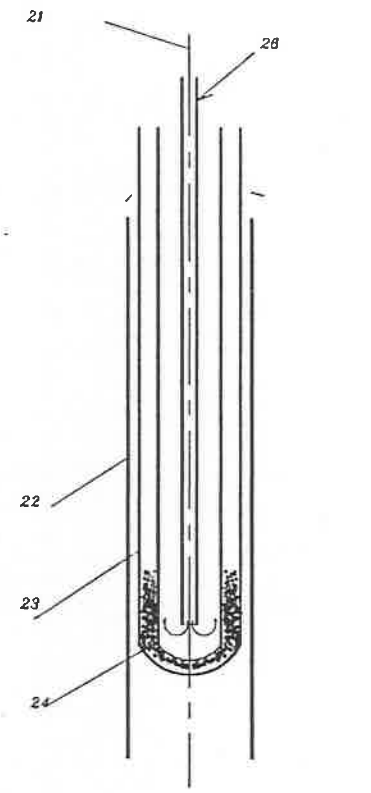


Figure 2

EXOTHERMAL POWER REACTOR

Inventors: R. Neelameggham, J.F.Reilly, M.Ciomek, G.Ramadorai, & K. Ganesan

DRAWN: R. Neelameggham April 10, 1989

steam space. This allows the partial pressure control in the steam space and thus prevent hydrogen (deuterium) explosion. The pressure vessel (1), acts as the outer anode and is separated by the cathode holder (14), by a pressure tight, electrically insulating material (12), capable of withstanding the atmosphere and temperature of elctrolyzer. The pressure vessel (1), is preferably made of nickel, or monel, or special stainless steel.

The entire electrolyzer with the magnet is kept thermally insulated to minimize heat losses to the surroundings. The items not shown in the figures are: the vapor driven power generating unit, coolant reprocessing unit, the direct current with superimposable alternating current power supply to the electrolyzer, and the system the activate the magnet.

Figure 2. shows the cross-section of one set of cathode-anode pair. Line (21) is the axis of the system. The anode (22), is made of nickel, or an alloy thereof, and is preferably made from a wire screen or a perforate plate, to allow free circulation of the electrolyte. The cathode (3), consists of an outer sheath (23), and an inner sheath (25). Inside of the inner sheath is the coolant inlet flow channels, which vaporizes while exchanging the heat from the surface of the inner sheath (25). Inside the annulus (24), between the cathode inner and outer sheaths, a suitable hydrogen (deuterium) absorbing material for the operation temperatures required. The outer sheath of the cathode is made of monel (which does not show hydrogen (deuterium) embrittlement, nor is its hydride (deuteride) reactive to water. The surface of the outer sheath is coated with a catalytic coating of palladium or vanadium. The catalytic thin film layer helps in the initiation of hydrogen (deuterium) diffusion into the body of the cathode through the monel into the annulus containing the hydrogen (deuterium) material selected for the specific temperature of the power generating system.

The process consists of initially filling the electrolyzer vessel with the electrolyte full removing any air inside the system. The electrolyte is usually made alkaline by adding potassium hydroxide to water (or potassium metal to heavy water) to provide a high electrolyte conductivity. Substitution by other alkali-metal ions alone or a mixture is also applicable.

The process starts by initially heating the electrolyte to the desired operating temperature, preferably, utilizing the alternating current through the electrolyzer leads (13) and (14). During this time, the valves (7) and (8), are kept closed to create the system pressure. The vapor space pressure is created without lowering the electrolyte level too much, which would expose the top of the anode. At this time, the direct current is adjusted to start the cathode hydriding (deuteriding) period. The electrolysis reaction during the hydriding period is as follows (deuteriding reactions are similar):

$$2\ H_2O \iff (2-y)\ H_{atom} + M_xH_y + O_2$$

where M_xH_y is the metal (intermetallic compound) hydride. Part of the product H_{atom} which is soluble in water (heavy water) recombines with the oxygen generating considerable heat. The excess oxygen bubbles into the vapor space, and will tend to increase the pressure, which is suitably relieved by operating the control valves, (8). The exothermic heat developed during the doping period, from both the metal hydride (deuteride) formation and the partial recombination is removed by vaporizing the coolant inside the cathode body.

Following the hydriding period, d.c. electrolysis is continued with the application of external magnetic field into the cathode to augment nuclear fusion type reactions (such as two hydrogen atoms combining to form deuterium) either inside the metal lattice or at the interface between the cathode and the electrochemical surface pressure is conveniently effected giving rise to additional exothermic heat. Overdoping of the metal (intermetallic compounds) also increases the heat generation. In order to accomplish these reactions, the electrolysis is carried out at high current densities, between 2 and 10 amperes/square inch, preferably around 5 amp/sq.inch. The current density selected is, however, a function of the pressure, temperature and voltage of operation.

The superimposed alternating current is used to alter the direct current density and control the operating variables at this time. When, the direct current is slowly turned down, the release of electrochemical pressure at the cathode surface will let some of the doped hydrogen (deuterium) escape back into the electrolyzer and facilitate additional recombination with oxygen inside pressure vessel in the electrolyte and steam space, the heat of this recombination is also removed by the coolant vapor driving the power turbine, or the prime mover.

In case part of the nuclear fusion type reactions give rise to the heat generation, some of the gaseous products such as deuterium, tritium, and helium along with the oxygen and steam are conveniently removed through the valve (8), through a quenching chamber, and inert gas separation unit (not shown). If any radioactive particles are generated, they are controlled by the coolant circuit and varying portions of the materials of construction.

Examples

1. 150 to 200 psig steam is produced for a steam driven turbine, using water as a coolant in the exothermal power reactor, utilizing magnesium, Mg_2Ni, Mg_2Fe as the hydrogen (deuterium) absorbing agent. The electrolyzer is operated at 400 to 450°F at a pressure of about 200 to 300 psig. The electrolyte is water (heavy water) containing 10 to 20% KOH.

2. Acetone vapor driven power unit was operated by the exothermal power reactor utilizing FeTi as the hydrogen (deuterium) absorbing agent in the cathode sheath. The electrolyzer is operated at 200 to 250°F, at a pressure of 30 to 50 psig.

3. A 400 to 500 psig steam is produced for a steam driven turbine utilizing titanium, zirconium or lithium as the absorbent in the cathode sheath, utilizing an eutectic melt of lithium and potassium hydroxide containing 5 to 10% water (heavy water) as the electrolyte. The electrolyzer is operated between 900 and 1300°F.

4. An electrolyzer utilizing yttrium or lanthanide metal cathode operating at 700 to 1600°F.

5. A modified cell utilizing mercury as a cathode showing the exothermal heat generation capability, is under construction for testing.

6. Another modification of the cell with graphite main body cathode, with several surface coatings such as copper-strike with palladium, copper-strike with mercury amalgam, etc., is capable of demonstrating the exothermal-energy generation. The cathode internals can conveniently be utilized to introduce a heat transfer medium in extracting the exothermal heat generation.

Claims *Filed.*

Lo-γ

Lo-γ (title is copyright of SHC; contact SHC for licensing privileges) section is being introduced in Let's Levitate to continue discussions on the recent cold-N-fusion (CNF) subjects.

* University of Utah has been awarded over $4.5 million grant by the State of Utah in establishing the National Cold Fusion Institute in Salt Lake City, Utah. U of U declares it as a non-Profit Research Center (August 6, 1989.)

* Utah State University researchers on Lo-γ CNF did not have the privilege of Funds from the State of Utah Fusion Council, during this round.

* Dr. Jones, et al, of Brigham Young University, have had more national acclaim on this subject (DOE, LANL, Nature.) BYU is a privately run University.

* Many controversial articles on this subject still seem to be published/announced both in mass communication press/media and in science journals.

* There is more confirmation of the excess heat generation than any positive confirmation of the so called CNF R_γ. [University of Utah Metallurgy Department Dr. M.E. Wadsworth, Dr. J.G.Byrne, Dr. S. Guruswamy, and others; Dr.Bockris, et al of Texas A&M; U of Florida; MIT news releases, etc.]

* J. Electroanal. Chemistry, 265 (1989) 355-360, has a preliminary note on the *'Examination of nuclear measurement conditions in cold fusion experiments'*, by D. Abriola and 25 others, from Department de Fiscia, Comision National deEnergia Atomica, 1429 Buenos Aires (Argentina). This explains the analytical difficulties in measuring CNF reaction intermediates, and lack of identifiable products by Conventional Analysis of the intermediates /products of CNF. This paper cleverly points out the need for unconventional analytical techniques.

* A July 89 National Public Radio

interview with the CNF experts at U of Florida, noted that Dr. Schoessow has found a switch to control the excess energy generation from their CNF experiments. Researchers are quite perturbed about their inability of explaining the excess heat, inspite of their measurements of tritium, mentioned in April. Dr. Schoessow, however, points out that their Electrolytic Apparatus is uniquely different than the ones by Dr. Pons, et al, seen in the press in March and April of this year.

Scuips

On May 30, 1989, J. Gopalakrishnan, A.W. Sleight, and M.A. Subramanian of E. I. Du Pont de Nemours & Co., were awarded the U. S. Patent 4,835,136 for their invention, *'Lanthanum: Sodium Copper Superconducting Metal Oxide Compositions and Process for Manufacture'*. This work was filed on February 4, 1988.

They claim the superconducting composition containing a metal oxide phase of the formula $La_{(2-x)}Na_xCuO_z$, wherein x is between 0.1 and 0.3 and z is between 3.8 and 4.2, which is formulated by mixing La_2O_3, Na_2O_2 and Cu and heating the mixture to 900°C for about 12 to 24 hours and furnace cooling it to 100°C. The T_c of the ambient quenched sample, following the removal from the furnace ranges between 10 and 30°K. (M. Ciomek, Connecticut Correspondent).

We at the SHC feel that, had they reoxygenated the composition to introduce the peroxide conversion in the matrix, they might have gotten higher T_c; at least they were on the right track in using sodium peroxide and enclosing the mixture under a pressure (which is insufficient in preventing the decomposition of Na_2O_2 when heated to 900°C).

* Over two dozen short courses in High T_c superconductors and related subjects have been mentioned as forthcoming, by TMS, ACerS, and other societies.

* The First International Ceramic Science & Technology Congress will have a session on '*Symposium on Superconductivity and Ceramic Superconductors*', with invited speakers from India and Japan, besides the s$T_c$alwerts from several US Laboratories.

The plenary lecture will be by C.W.Chu. The conference will be held in Anaheim, Ca. between Oct 31 and Nov 3, 1989. Contact ACerS Meeting Registration, Department 315, Columbus, Ohio 43265.

* The New York State Institute on Superconductivity, Buffalo announces their Third Annual Conference on Superconductivity and Applications, at Buffalo Hilton between September 19 and 21, 1989.

Contact: Dr. R. S. Hamilton, NYSIS, 330 Bonner Hall, SUNY @ Buffalo, Buffalo, NY 14260, (716) 636-3463.

* The Office of Technology Assessment (OTA) and NSF published their preliminary analysis of the high temperature superconductivity portion (HTS), recently.

* Over $80 million of US Industrial Research Funds was spent on high temperature superconductivity (HTS).

* 107 small businesses were involved in HTS.

* ORNL, in collaboration with EPRI, has announced their forthcoming axial-bandgap-superconducting-motor using hi-T_c materials. Their initial tests will be made using the conventional cryogenic superconductors - using niobium-titanium magnet operating at 4°K generating 180 hp.

* IBM has advertised their *'the 1989 IBM Superconducting Competition'*, inviting

people to submit accomplishments, to honor those individuals whose imagination has elevated the state of the art in analysis and modeling. Call 914-686-6318, in Canada (416)-758-4136.

* Nova Science Publishers, 283 Commack Road, Suite 300, Commack, NY, 11725 (516-499-3106), have announced their three volume publication *'Studies of High Temperature Superconductors'*, Ed. A.V. Narlikar, NPL, India. These three volumes contain articles on hi-T_c by authors across the northern hemisphere.

A.K. Ganguli, et al (Bangalore, India) report their formulation of TlSrLnCuOxide with T_c around 40°K.

SHC Forum

* The local chapter of SHC, Las Vegas, held its meetings towards the end of May 1989. It was interesting to note that anodizing titanium to different colors was prominent among the discussions. John Priscu, recipient of the International Award for Titanium Technology Excellence 1988, Europe, brought forth the highlights of anodizing titanium to bring more colors unto metallic titanium substrate; showed samples of his work done in the late 1950's. He also showed the colorful books on *Drawings on Titanium, by Pietro Pedeferri, Milan Italy.* Mr. P. Chelliah of DOE, Washington, was in attendance and provided useful insights.

Other discussions, included the techniques developed by Ceracon, Inc., California, on formulating YBC hi-T_c using a pressure transmitting medium to squeeze part PRE-forms at controlled temperatures and pressures to align the crystal structure in making the hi-T_c formulation.

* During June 1989, SHC Committee visited its local chapter in Buffalo. Dr. Radha Ranganathan, SUNY N Buffalo Campus, Dr. G. V. Srinivasan, SOHIO Research NY, were in attendance.

The visit to London, Ontario, Canada, mainly involved the discussions on Biological Transmutations by Dr. Kervran as well as the difficulties of CNF detection in an alkaline medium, such as LiOD/LiOH.

Kervran's Biological Transmutations

Dr. C. Louis Kervran's treatise on Biological Transmutations, was originally published in French in 1962. This was followed by International Confirmation from Japan, England and Canada. His work was mainly known to Soil Chem-biologists. It was translated into Japanese, before its Canadian translation.

Dr. Kervran's English translation was available in the US during the 1970's. Basically, Dr. Kervran indicates the possibilities of low temperature transmutation possibilities by yet-unknown enzymatic catalysis. His book has results from hundreds of inorganic analysis in the biological systems where the quantities of one or more elements change to result in the increased mass of other elements. This book is a MUST Reading reference for anyone working in the field of Lo-γ.

It is difficult to refute Mendelev and Einstein, though, it is not difficult to condone others who believe in less. This does not make one a scientist. A scientist appreciates that Tulips bloom in Spring and that there is a possibility of creating similar conditions to make them bloom in October in Yukon.

SHC encourages its readers to read this treatise, which claims nothing, yet explains the possibilities of low-temperature transmutations.

Experimental analysis and hypothesizing after the fact, or hypothesizing before the fact, setting up experiments and evaluating of the results in its own light, are more pertinent to being a scientist. Whether the results follow the hypothesis or correction of hypothesis follow the experimental observations, both are very scientific. Conventions do need to change, preferably following better defined hypotheses. They do change, abruptly, unfortunately, at times due to FHG (a fallacy noted in Inductive Logic, Fallacy of Hasty Generalization). This trap has to be avoided by those who claim to be true scientists. There is nothing wrong in admitting mistakes, and reevaluating one's stand.

* The Trekkies of SHC want to announce that they are in the process of trying to generate DILITHIUM to be able to power their Enterprise by electrolysis.....

* The Department of Fusion Confusion's Official 1989 Kit, $6, claims to work with any desired beverage kept in the cup, for everyone except those affiliated with Boston Physicists or those from Boston.

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A Geometric Model Of Superconducting Structures

Erik W. Kvam

Erik W. Kvam, Superconductor Ventures, L.P., New York, has prepared a detailed thesis on the above topic. His efforts in stimulating scientific interest in a simple model which can predict the superconducting properties of a material based on the valence bond structure, is a welcome change to us hobbyists. An abstract of his thesis is presented below.

Superconducting materials possess interatomic structures, and localized and de-localized valence electron and hole orbital state structures which produce superconductivity. De-localized electrons and holes flow along isotropic circumferential or geodesic energy vectors of a de-localized valence electron and hole orbital state structure, referred to as the "*superconducting structure*". The superconducting structure is an isotropically space-filling tetrahedral-octahedral net structure. The superconducting structure is interstitial to a net structure of isotropic energy vectors connecting cubically ordered localized valence electron and hole orbitals interstitial to the atoms of a superconducting material. Such superconducting structures are incorporated in superconducting materials.

The structures described herein produce the following properties or effects characteristic of superconductivity in copper oxide superconductors: (1) increased T_c with multilayer structures, (2) microstructural twinning, (3) photoemission spectroscopy evidence of oxygen dimerization, (4) oxygen stoichiometry and copper-oxygen chains $YBa_2Cu_3O_7$, (5) Jahn-Teller distortion of copper-oxygen half-octahedra, (6) antiferromagnetic and ferromagnetic normal states, (7) anisotropic critical current, anisotropic resistivity, anisotropic upper critical field and evidence of hole and electron charge carriers, (9) metastable glasslike behavior, (10) photoemission spectroscopy evidence of Cu-3d/O-2p conduction band, (11) zero resistivity, 12 (AC Josephson effects and Cooper pairing, (13) short intralayer superconducting coherence length, (14) Meissner effect, (15) hexagonally correlated flux quanta and type-II superconductivity, and (16) positron annihilation results.

Scuips

J.T. Chen et al (Wayne State) have reported that the formula $Y_5Ba_6Cu_{11}O_y$ shows stable-zero resistance around 240°K ... presenting the XRD pattern, v vs. t at constant i (amplitude), v vs. t at constant i (amplitude), i-v curves at various temperatures, dc voltage vs. dc magnetic field and the temperature dependent zero field cooled and field cooled magnetization vs. temperature. No Meissner effect simpleton experiments have been discussed.

Among other compounds, it has been noted by Hongbao, et al, that the concoction $BiPbSbSrCaCuO_z$ shows a zero resistance around 130°K. It's interesting that science is becoming 'Who's the better chef?'

CSAC News release of October 10, 1989, announced four new additions to its Board of Directors for 1990. CSAC Chairman Dr. G. A. Keyworth II, stated that: These individuals (K.V. Adams, Lockheed, Peter Cannon, Conductus, Inc., J.M. Swartz, Lake Shore Cryotronics of Westerville, Ohio, and G. M. Yurek, American Superconductor, Inc. Mass.) bring a wealth of entrepreneurial experience to the CSAC effort (in addition to the existing 22 person Board of Directors of the Council on Superconductivity for American

Competitiveness) to make America competitive in the emerging technology of superconductivity.

CSAC is a non-profit, non-partisan, educational association of industries, universities and laboratories founded in 1987 to pursue U.S. competitiveness in superconductor technology, with 55 member organizations and is privately funded. Others interested in joining this group should contact Rob Kiernan, CSAC, 202-965-4070. Among the major organization efforts of CSAC the following are noteworthy, '... to organize Sc Maglev Coalition', ' Review of all major policy issues regarding applications of basic research into advanced superconductors', and ' drafting of a 5 year National Action Plan on Advanced Research and Development'.

The article "Apprehensive About Applications" in *Superconductor Industry,* Fall 1989, is a valuable reading for SHC enthusiasts.... "Are Applications for high T_c superconductors imminent or will we have to wait until the 21st century before they become a reality?" tries to present another opinion. Both views have their proponents but the truth lies somewhere in-between.

Biological Transmutations

Geetha Ganesan

After the announcement of nuclear fusion by Pons and Fleischman there has been a lot of interest about it. Nuclear fusion is a process in which two (or more) different low atomic weight nuclei combine to give a higher atomic weight nucleus. The difference in the atomic weight of the resultant nucleus from the sum of the low atomic weight nuclei is liberated as energy. (Einstein's principle).

There can also be a nuclear reaction in which two nuclei combine to give a third nucleus and the reaction is known as transmutation. There has been apparently no mass difference between the initial and final product. Nuclear transmutation was observed first by Ernest Rutherford, when he bombarded a nitrogen target with α particles. The reaction produced oxygen and proton.

Professor C.L. Kervran found evidence for transmutation of elements in nature. Examples of transmutation of elements are discussed below.

It is known that a hen's egg shell is made up of calcium. In one experiment, although their diets did not contain any calcium, the hens could still produce eggs with shells made up of calcium. But the hens were observed to peck incessantly at the mica (potassium aluminum silicate) on the ground. When the hens were kept in a place with no source of mica or calcium they started producing soft shelled eggs which contained no calcium. When the hens were supplied with mica they pecked continuously at it and started producing normal eggs. The above experiment showed that the constituent elements of mica transformed to provide calcium needed for the egg-shell.

In one of C.L. Kervrans's experiments, the lime (calcium) in the egg was monitored when the egg was kept in incubation. The lime in the hen's egg remained constant for ten days and started increasing there after as shown in the figure.

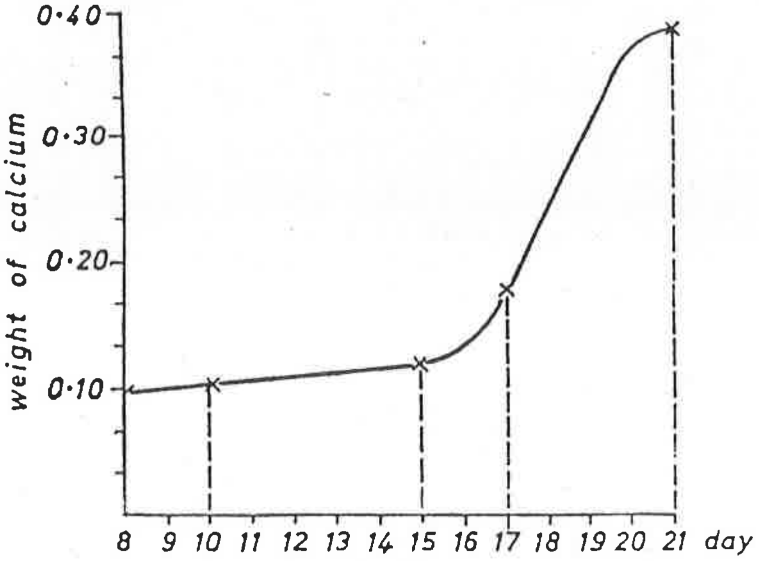

Fig. 1 Variation in the calcium rate inside a hen's egg during incubation (no change between the first and eighth day). (According to Prout's analyses)
Compare with the graph according to analyses of Delezenne and Fourneau in *Transmutations à faible énergie*". (*Low Energy Transmutations*).

At birth the chicken's skeleton had four times more calcium than was present in the combined yolk and white of the egg. The internal layer of the egg has a membrane which is made up of silica.

The following study, by C.L. Kervran, also observed the transformation of silica into lime.

In order to have a good lawn, the soil must contain calcium. But when the calcium is exhausted, daisies appear. The ashes of the daisies, when analyzed, were found to be rich in calcium. Where does this calcium come from? Since, there isn't any in the soil? The daisies grow only when there is silicon along with suitable micro-organisms present in the soil. When these daisies die, the soil gets back its normal supply of calcium for the lawn to grow again.

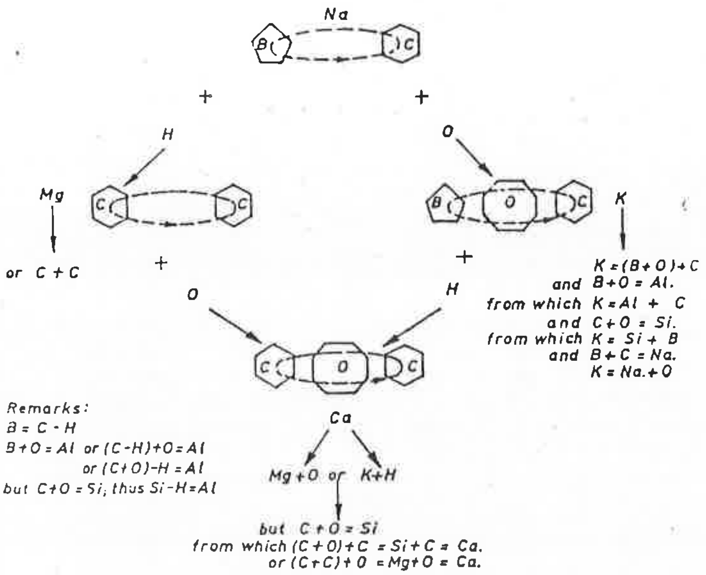

Fig. shows the main biological transmutations. Each polygon represents a nucleus of a number of corresponding protons: 5 for Boron B; 6 for Carbon C; 8 for Oxygen 0.

Explanation for transformation of silica into lime (Prof. Kervran preferred a boron structural basis model):

An element is made up of an atom consisting a central nucleus with electrons around it. The nucleus includes the protons and the neutrons. Silicon has 14 neutrons and 14 electrons. Carbon has 6 neutrons and 6 electrons. Silicon combines with carbon to form calcium. Calcium has 20 electrons and 20 neutrons...., thus,

$$ {}_{14}Si^{28} + {}_{6}C^{12} = {}_{20}Ca^{40} $$

Many things which remained obscure in the past could be explained with the knowledge of nuclear transmutation in a number of fields like chemistry, physics, geology, agronomy, medicine, etc.

Lo - γ

A lot more is happening in this field during the past few months. What with all the different inferential analysis of what's happening (out there) inside the cells which produce heat, heated discussions, tritium or not tritium, x-rays instead of γ rays, etc. ... all intriguing and interesting. This subject has in recent times been renamed as *"Electrochemical Heat Generation"*.

Dr. Ramesh Kainthla, of Texas A&M, privileged to press talk, along with Nigel Packham, an associate, *'pressed'* that their group directed by Dr. Bockris, has been able to show heat equivalence to tritium production in their cells of September 1989.

Dr. Oriani, U of Minnesota, Dept. of Chem. Eng., is known to have lot of in-site on (confirmation of cold NF) *lo*-γ, was to have visited the National Cold Nuclear Fusion Institute, Utah during the week of October 9. His paper will be presented at the Hollywood, Florida E.Chem. Soc. meeting on October 20, 1989.

An invited seminar is arranged by EPRI and NSF in Washington, D.C., during the week of October 16, 1989, on exploring the Cold *NF* potentials... a current topic.

Early part of October, saw considerable Network discussions of a recent paper by Iyengar, et al, of BARC, India. Active participants in the discussions include those from Rochester, Los Alamos, etc. An *in situ* emulsion filming technique on the active titanium cathodes indicated occasional release of titanium K-α ***x-rays.*** Confirms that something is happening in there.

Here is an excerpt quote from a column by Christopher Smart, Salt Lake Tribune Staff writer's article '*For Fusion, Never Fear, PR's Here*'.

> "FUSION: A Pretty Great Solid State. ....A recent opinion poll shows that 65 percent of Utahns believe that cold fusion does exist. Any day folks in Laramie and Twin Falls will believe it, too. Then it will be only a matter of time before people as far away as Des Moines and Dubuque and even folks in Poughkeepsie will believe in cold fusion".......

We wonder if the extra-terrestrials who visited Siberia (Tass report with pictures) used di-lithium power in their trip out to the cold... is it to replenish their power system???

More on cold fusion and brown dwarfs illuminated by this kind of reaction can be found in the letter by C. Sivaram, World Laboratory, Switzerland, in Nature (Vol 341, Sept. 7, 1989, pp 28).

Quote from Fundamental Concepts of Inorganic Chemistry, E.S. Gilreath, (McGraw Hill Book Co., 1958, pp 357).

> 'The first production of high-speed protons with sufficient energies to cause nuclear transformations was achieved by Cockroft and Walton in Rutherford's laboratory in 1932 by means of high-energy discharge tubes.
>
> Cockcroft and Walton observed that high-speed protons striking a target of mica containing a lithium salt caused a disintegration of lithium atoms into alpha particles.
>
> The nuclear equation for the reaction is ${}_3Li^7 + {}_1H^1 = 2\ {}_2He^4$.
>
> Not only was this the first truly artificial transmutation to be produced,....'

Muons and Us

Sometimes we wonder when they talk about Muons if they are putting Us ON. Never fear, it is just another particle; smaller than dust. Why is it that muons are connected to cold nuclear fusion, another question you may ask? Don't worry, the following excerpt from New Scientist, 25 April 1985 (pp 38-40), by Nina Hall, comes to our rescue.

'Muons were first observed in cosmic rays in 1936. ....their existence is still something of a mystery. A muon is very much like an electron....but 207 times as heavy...lives for little more than 2 microseconds, before decaying into an electron (or positron) and two neutral particles called neutrinos [mass reduction surely becoming energy].

The possibility that muons could catalyze fusion was first suggested by F.C.Frank at the University of Bristol as early as 1947. Some of his colleagues, led by Cecil Powell, believed that they had found evidence for a new particle which decayed into a muon. Frank was offering an alternative explanation for Powell's data, but Powell was right, and had indeed discovered the particle now known as the pion, and Frank's work could have sunk into obscurity.

But shortly afterwards, Andrei Sakharov and later Ya. B. Zel'dovich picked up and considered further the process of muon-catalyzed fusion.

Frank originally considered the fusion of hydrogen and deuterium. If a negative muon enters a target of hydrogen it will slow down and knock out and replace an electron in one of the atoms. It thus quickly forms a "muonic atom" in which the muon orbits the single proton of the hydrogen nucleus. If there are any deuterium or tritium atoms around, the muon will soon transfer to the heavier isotope, because its binding there is preferred energetically. The muon is much heavier than an electron, so it is held much more closely to a proton or deuteron. The neutral object formed is in fact so small that it resembles a neutron. In this guise, the muon and deuteron can together approach another hydrogen nucleus to form a so-called meso-molecule, electron is thrown out. The two nuclei vibrate rapidly and there is a high probability that they can come close enough for the strong nuclear force to overcome the electrical repulsion. The nuclei then fuse to form a nucleus of helium-3, at the same time releasing muon. The fusion occurs very quickly, in about one picosecond.

This sequence of events was accidentally observed by Luis Alvarez and his group at Berkeley, California, in 1956.

Two theorists, S.S.Gerstein and L.I.Ponomarev, suggested in 1977 that, rather than emitting an electron during the formation of the mesomoleule, a very peculiar molecular species is formed.

Experiments in the USSR on deuterium-deuterium reactions and some limited results for deuterium-tritium confirmed the theoretical predictions, showing that the mesomolecular formation - and hence fusion - could speed up enormously in the right temperature of about 100°C. Again, scientists started to think about fusion power. The sticking probability had to be measured.

A Practical Fusion Race

At this point in the beginning of the 1980's, American scientists started to take a serious interest. Steven Jones and his group at the Idaho Nuclear Engineering Laboratory decided to test the Soviet predictions for deuterium-tritium fusion and to measure the sticking probability. They began experiments at the Los Alamos Meson Physics Facility in collaboration with Mel Leon and other physicists there. By the beginning of 1983, they found that a deuterium-tritium mixture with 60 per cent the density of liquid hydrogen, indicated an average of 90 fusions per muon at 127°C. It was the first time that anyone had measured a practical fusion rate and the researchers were well pleased. Moreover, their results were consistent with a sticking probability of about 1 percent. '

> ....An energy of about 5 gigaelectron volts is required to produce one negative muon, while the fusion energy released is on 2 GeV per muon, assuming that one muon catalyses 1200 fusions. .... To obtain break-even between the energy used and produced in pure muon-fusion would require at least 300-400 fusions per muon, ... pions, ... and .. muons, are produced using proton beams and carbon targets. ... "

In the same section notes by John Davies and Christine Sutton indicate that some of the work by Steven Jones and LANL in the early 1980's using a target of liquid deuterium and tritium, held at 25 ° K or less showed rates of 170 +/- 25 fusions per muon.'(....this iiiis really cccold.)

With all this background, one should not be surprised about various options in obtaining cold nuclear fusion.

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Fusion Royale

Neale Neelameggham and K. Ganeshan

We at the Superconductivity Hobby Club, predict that sustained economic fusion will happen in the following experiment designed to simulate the main effects in the sun. Carbon-proton fusion cycle which can be simulated by comprehending Haber synthesis in an ordinary water high-voltage (if necessary up to corona levels) direct current electrolysis (initiating period of very short duration) using a nitrate or ammonium salt for initial conductivity boost, and providing the nitrogen nucleus. After all, does not this simple cycle sustain growth of life, fusion of cells (no pun), etc.

Our postulations and proven breaking of other metals such as vanadium in 3 hours and mercury in five days, known to our readers from the previous issues are available to others upon request.

News Excerpts

A. Khandkar

o EPRI and NSF held a joint workshop on cold fusion October 16-18,1989 in Washington D.C. to discuss the heat anomalies exhibited by deuterated Palladium in "hacqueous" electrolytes (cold fusion). Dr. John Appleby of Texas A&M and Dr. Paul Chu of University of Houston (of high T_c fame) co-chaired the workshop. Dr. Edward Teller (of H_2 bomb, or, hot thermonuclear fusion fame) and Dr. Martin Fleischmann were keynote speakers for this workshop. The meeting was aimed at identifying key research issues essential to understanding the phenomenon.

The conclusions reached by the workshop participants were that the observed heat anomalies cannot be explained as a result of artifacts or errors and that possible correlations among the various efforts are still lacking. The participants further concluded that in view of the potential significance of the problem, further research would be necessary to evaluate the overall understanding of the efforts. (EPRI, Exploratory Research Letter, Nov. '89).

o One of our Editors visited various Japanese R&D Labs recently.

Sanyo Electric Co. Ltd., is pioneering the use of plasma-arc melting and rapid quenching techniques for developing high density superconductive materials. The work being carried out at the Functional Materials Research Center, is also focussed on full scale production. Applications include cryoelectronics devices such as SQUIDS.

An innovative device is the Meissner Motor, which utilizes the Meissner effect. The motor has a rotor made of 123 compound. When cooled to liquid nitrogen temperatures, the rotor levitates. A small temperature difference (between the rotor vanes dipped in liquid nitrogen and those above) causes the rotor to rotate continuously, consuming no energy during operation (Perpetual Motion Machine?).

More On A Geometric Model of Superconducting Structures

In the last issue we mentioned briefly about the theory "*A Geometric Model of Superconducting Structures*" by Dr. Erik W. Kvam. Dr. Kvam would appreciate our readers to contact him directly regarding his theory applicable in generating newer superconductors at the address given below:

Erik W. Kvam, 9 East 32nd Street, New York, New York 10016
Tel: 212-315-5575(day) 212-889-2383(eve)

Some of Dr. Kvam's propositions are excerpted and are noted within quotes.

"The present model describes interatomic structures, localized valence electron and hole orbital structures and superconducting structures common to such superconducting materials.

"The model does not employ mean-field band theory, yet the model's geometric principles may have intuitive appeal to both physicists and chemists.

"The structures described herein are space-filling tetrahedral-octahedral structures and space-filling dual-tetrahedral/cubic structures termed 'net' structures. Understanding superconductivity requires understanding of the physical and chemical properties of such net structures... which describe the geodesic flow of delocalized electrons and holes.

"Energy relationship among particles are expressed in terms of energy vectors, which function as a quantum 'spring' or 'oscillator', capable of expressing wave functions."

The beauty of Dr. Kvam's theory is in the ability to express the Schroedinger's wave theory combining with the intuitive Buckminster Fuller's ideology that even macroscopic stability is easily explained by three dimensional triangular models. We feel that Dr. Kvam may have predictions of what's to come utilizing his geometric model, not propounded in his present thesis.

SC Forum

The International Superconductor Applications Convention will be held Onboard the Queen Mary, Long Beach California, USA between January 17 and 19, 1990. Topics on both low and hi T_c applications in the fields developed mostly by the US sponsors of the Superconductor Application Association will be presented in this conference.

The subjects include: sensors, Magnetic Separations, Computers, Signal Processors, Miniature Antennas, Bearings, Microwave/Millimeter Wave Sensors, Focusing Electron Beams, Electric Automobiles, Gas Separation, Communications, Infrared Sensors, Gravity Calorimeter, Data Transmission, Missile and Aircraft Guidance Systems, Magnetic Levitation, etc. as noted in their Convention Brochure. Those interested should contact, Superconductor Applications Association, 24781 Camino Villa Ave., El Toro, CA 92630 USA. Call 714-586-8727. Members of SHC/Lets Levitate will get a discounted one day registration for $135.

SCUIPS

Dr. John Goodenough received Von Hippel Award from the Materials Research Society in November 89. A professor of materials science and engineering at the University of Texas at Austin, Goodenough was being recognized for '*distinguished multi-disciplinary research which has established the conceptual foundations of the science of solid state chemistry.*' We at the SHC esteem persons such as Dr. Goodenough for appreciating the effects and the role played by non-metal oxygen in the recent high T_c race.

The following is quoted from MRS Press Release:

'Goodenough is presently concentrating on the origin of the high-T_c phenomenon in the copper-oxide superconductors. These oxides exhibit superconductivity in a narrow compositional range where a transition from localized-electron antiferromagnetism to itinerant-electron metallic behavior occurs as a result of changes in the strength of the copper-oxygen-copper interactions. Goodenough has pointed out that, in addition, the phenomenon occurs in the narrow-band limit for mixed-valent oxides where small-polaron behavior is transformed to itinerant-electron behavior as well as the cross-over for the equilibrium reaction
$Cu^{3+} + O^{2-} \Leftrightarrow Cu^{2+} + O^{-}$

To date, theorists have tended to concentrate on one or another of these special features; Goodenough suggests that it is the confluence of all these features that gives these copper oxides their unique superconductive properties.'

Readers of the SHC might remember the Peroxvite Theory of Superconductivity, published in 1988.

Frost & Sullivan have announced that their report #A2044 entitled 'Emerging Market Opportunities in Superconductivity Applications' published in Summer 1989 is available for $1750. Their estimate for 1988 US merchant market for super-conductor based products was $110 million, mostly for the low T_c magnets, cryogenics, cables, NMRI,etc.

They predict an annual growth of 35% to a 1993 market expectancy of $500 million. The report is some 206 pages long, from identification of emerging end user markets and applications for the technology through a market forecast including analysis of the supplier industry structure, their competitive aggregate industry rank and share tabulation, etc. Those interested contact, Frost and Sullivan Inc.,106 Fulton Street, New York, NY 10038-2786. (212-233-1080), or any of their other branches in London, Frankfurt, Paris, Milano, Tokyo or Sao Paulo.

The recently issued 1988 Annual Report from the Center for Advanced Materials, Lawrence Berkeley Laboratories, includes a section of their accomplishments in high T_c field. Noteworthy are their work in the synthesis of the $La_{2-x}M_xCuO_4$ (M=Ca, Sr, Ba) and $Ba_{1-x}K_xBiO_3$ utilizing fused NaOH/KOH melts around 300°C, and thermocompression bonding of aluminum cladding to YBCO with thin silver interfacial layer.

Excerpt from Cold Facts, November 1989. -- 'MMR Technologies have developed a new Joule-Thompson Refrigerator which cools to 68°K utilizing vacuum assist on the gas exhaust port and gas input pressures of 1100 to 1800 psi. For more information, contact Robert Paugh, President, MMR 415-962-9620.' This refrigerator would be a nifty addition to those working with high T_c superconductors.

US Senator Domenici announced on November 3, 1989 that agreement has been reached by the House and Senate conferees, on 'Technology Transfer Legislation' which was initiated three years ago by him. This initiative will improve collaboration and exchange of knowledge between national labs, industry and universities. This bill will be known as the National Competitiveness Technology Transfer Act of 1989, and is included as an amendment to the Department of Defense Authorization Bill.

ICI and AT&T announce their construction of a practical radio frequency and microwave cavity resonators using HTS. Contact Vic Burris, ICI Advanced Materials (302-886-3290) or Russ Glover, AT&T Bell Labs (201-564-4097) for further information.

Why not other compounds-1989

Neale Neelameggham

It has been over a year since this column has been written. No breakthroughs have happened, other than the usual minor variations studied by scientists.

Z.Z. Sheng et al. (Department of Physics, University of Arkansas, Fayetteville, Arkansas 72701) have prepared a report "Empirical Search for Higher Temperature Perovskite-Type Oxide Superconductors". Among the compounds studied by this group, samples of $MTl_2Ba_2Cu_3O_{10}$ with M=Zr or Hf have shown superconductivity near 90°K, while when titanium is substituted for Zr or Hf the T_c is lowered below 15°K.

Bokhimi and Garcia-Ruiz (Mexico) report T_c values of 90°K in $Ba_2YCu_2WO_{9-y}$, which is supposed to have a cubic structure. They also found that W can be totally substituted by Mo, Nb, Ta, Sb, Sn, Bi or Pb to generate single phase cubic crystals with T_c's around 77°K.

Lo γ

Two 10-year-olds, Scott Bromley and Matthew Snow of Valley View Elementary School, duplicated University of Utah's cold fusion project for their school's science fair. Though Matthew admits that he was not very knowledgeable about cold fusion before this project, he indicates that it can bake six million pieces of toast with just two-thirds of an ounce. It can heat your house for a year in just two-thirds of an ounce. *(The Salt Lake Tribune, Dec.20, 1989 article by Donell Bates).*

Dr. Fritz Will, an expert in fuel-cell work, formerly of GE, has been selected to become the Director of National Cold Fusion Institute.

Nagoya University (Japan) scientists, Nobuhiko Wada, et al., reported in November 1989, that a flask filled with deuterium gas and palladium electrodes, following an initial soak for 55 hours and a 12000 volt zap for a couple of minutes produced 692 neutrons (not 691 nor 693!).

This is almost a similar experiment to the one done in Italy during April 1989, (although the zapping was different). Some science fans wonder why this experiment produced neutrons instead of tritium.... A plausible explanation is that this experiment, did not have the other reactant, lithium which is essential in the production of tritium... Don't we remember the earliest artificial transmutation experiment of 1932....

Professor Yoshiaki Arata, Osaka University claimed that his experiment produced as many as 100 meganeutrons per second for a sustained period of over 40 hours (some two megax compared to noise...ie. background). Arata's experiment followed the conventional (lat 9 months) approach of electrolysis. His paper is to appear in the December issue of the Journal of Plasma and Nuclear Fusion.

Dr. K. S. Iyer, BARC, reports that continuous neutron diffraction of the Pd-D_2O electrolysis shows that the detectable form of PdD_x varies between $x=0.44$ and 0.55. SHC feels that his report shows one of the best experimental evidence of non-compounding of Deuterium past the initial doping period, and proves credence to the age-old occlusion which may be taking place in this charge-(hot) discharge/atomic recombination thermal effects.

It is a pity that there is no single report to date that shows the overall material and heat balance from time zero of test to the bursting time, either proving or disproving thermodynamics or Einstein....

We can still hope for Santa to come down the chimney and give the pertinent reports to make science fans enjoy the Holiday Season.

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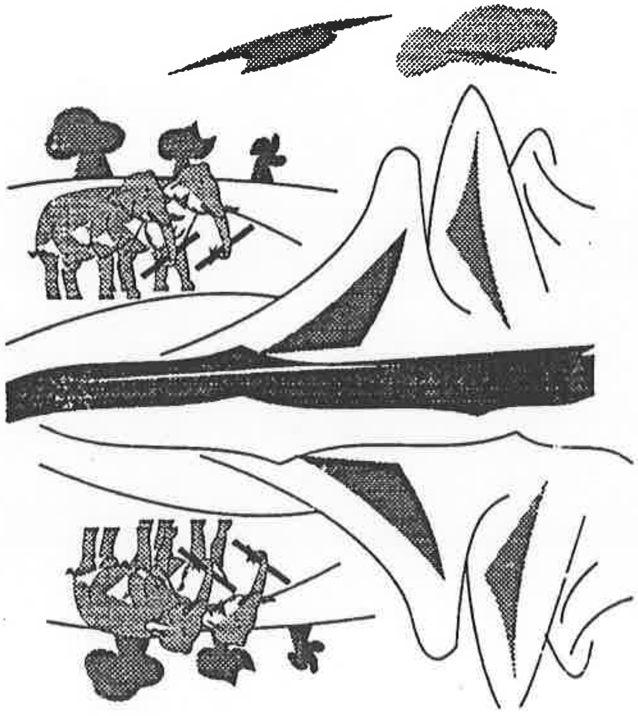

Seasons Greetings